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SIBLEY COLLEGE LECTURES.—1887-88.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

II.—THE HUDSON RIVER BRIDGE AT POUGHKEEPSIE, N. Y.

By THOMAS C. CLARKE, C.E.

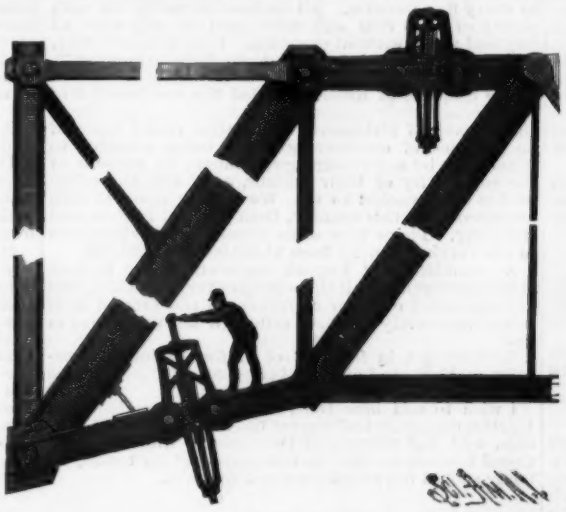
GENERAL DESCRIPTION.

MODERN bridge building is the creature of the railway system, and its productions are as different from the stately stone arches of our ancestors as is a locomotive from a Greek chariot.

There are now 150,000 miles of railways in the United States, and it is estimated that there is at least one bridge of 100 ft. long to every mile. This gives over 2,800 miles of bridges, chiefly of iron and steel. Where so many have to be built in a short time, æsthetic considerations are little regarded. Utility alone governs their design. So long as they are strong enough, few care how they look.

I make these preparatory remarks before showing you a view of the bridge now building across the Hudson River at Poughkeepsie, N. Y., by myself and my associates, to prepare your minds for the fact that it is not "a thing of beauty," although we hope it may be "a joy forever" to its stockholders.

It is, however, a considerable piece of engineering. It is one of the great bridges of the world. The work of construction has been carried on



WEDGES BETWEEN CANTILEVER AND HANGING TRUSS.

with extraordinary rapidity, and serious difficulties have been successfully overcome in putting in the foundations, which go down to 130 ft. below tide.

The object of this bridge and of its connecting railways is to deliver coal into the *interior* of Massachusetts and other New England States as cheaply as it is now delivered by water to the seaboard towns.

There will be a considerable saving in the cost of freight, and an avoidance of two transshipments, each of which injures the value of the coal from 5 per cent. to 10 per cent.

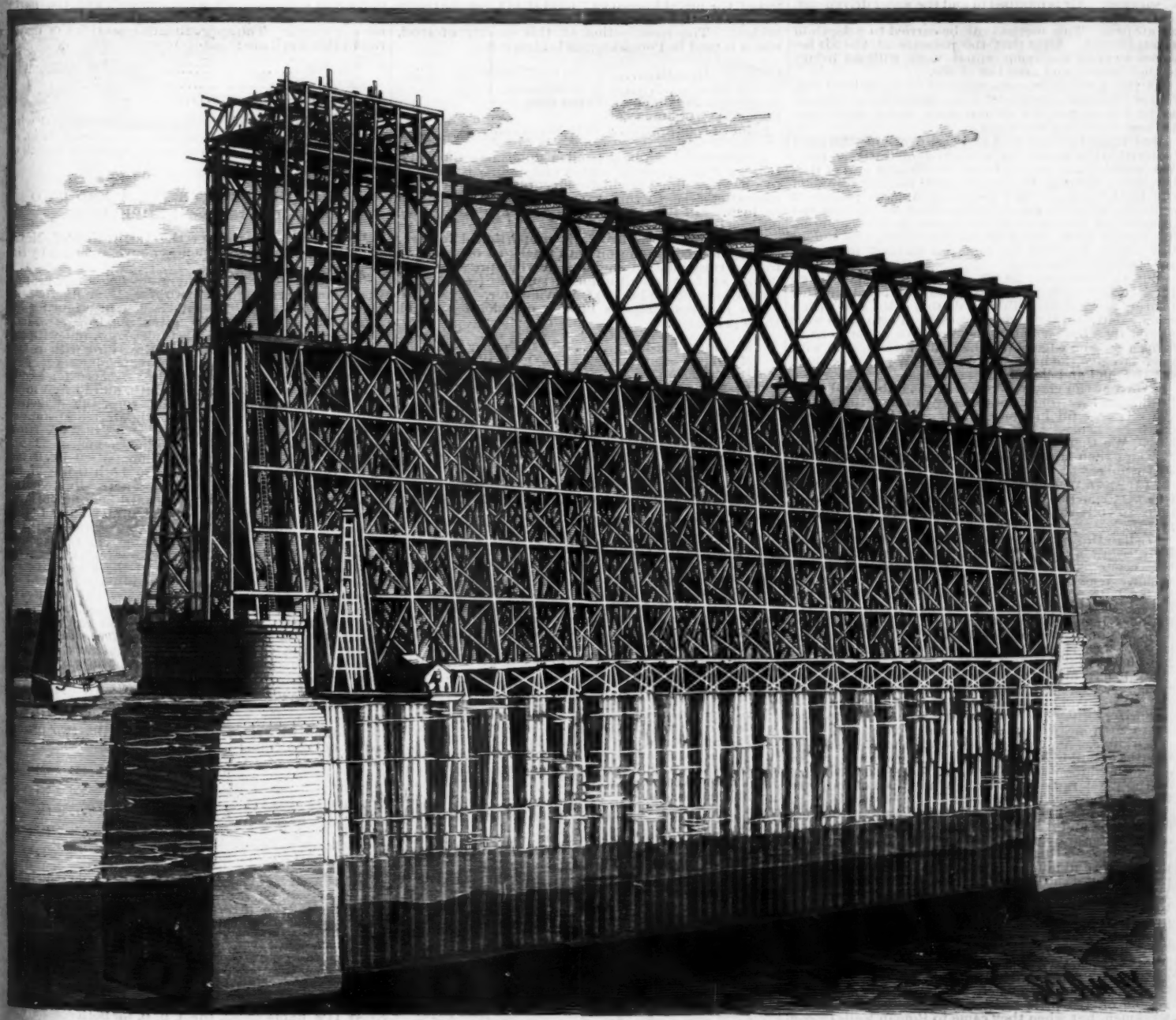
This will develop the manufactures of the interior towns and cities, just as those of the seaboard towns have been developed by cheap fuel.

Heretofore the Hudson River has stood in the way—a formidable barrier, both legal and physical.

As a legal barrier, it was removed when the legislature of the State of New York grasped the idea that those who wish to cross a river have equal rights with those who wish to go up and down it.

As a physical barrier, it was removed when we learned to build bridges of 500 ft. span and over.

The navigation of the Hudson is chiefly carried on in canal boats, which are united, forming a mass often 150 ft. wide by 700 to 800 ft. long, and consisting of 70 to 80 boats in number. These are towed by powerful steam tug boats, and the value of one of these big "tows," as they are



TRESTLE WORK OF THE HUDSON RIVER BRIDGE, POUGHKEEPSIE, N. Y.

called, reaches into the hundreds of thousands of dollars.

Certainly no piers should be allowed in such a river near enough to impede or endanger the passing of these valuable "tows."

The matter was carefully considered by the original projectors of this bridge, some ten years ago, and by the advice of that great engineer Capt. Jas. B. Eads (whose death we all deplore), the piers were fixed at a clear distance of 500 ft. apart.

The plans were also submitted to the government engineers, and approved by them before construction began. They pointed out that the spaces between the piers were wider than many of the navigable channels on the Hudson itself, and wider than the entrances to several of our important harbors.

I was on the work last year nearly every day, and during the season of navigation I saw from three to eight large tows pass every day. None had the slightest difficulty in passing. I have seen three tows pass together through one span, although partly blocked by our own construction barges. There will be five spans available when the bridge is finished.

The Hudson is a great trough, about half a mile wide, lying from 300 to 500 ft. below the general level of the country on each side. At Poughkeepsie, it has 60 ft. of water, and 70 ft. of mud and silt. Below this there is a deposit of very hard gravel and bowlders of varying depth, and the rock is found at from 150 to 200 feet below tide level.

As the banks and the country on each side are so high above the stream, it was necessary to build the bridge 212 feet above water, and place the rails on the top of the bridge.

The river part consists of:

Three cantilever spans of.....	548	ft. each.
Two connecting spans of.....	525	" "
Two shore spans of.....	201	" "

Total length of river bridge 3,094 ft., besides which there are viaduct approaches on each side, making a total length of about one mile and one-third.

FOUNDATIONS.

A pier is an artificial island. There are three ways of making them. One is the old fashioned plan of inclosing part of the river with a water tight structure, called a coffer dam, pumping out the water, and building upon the bed of the river so laid dry. This can be carried to about 30 feet in depth.

Another method is by using compressed air. The pier is carried by an inverted box called a caisson, made of wood or iron, placed in the water open side downward. Air is pumped in and the water driven out, and men go down inside by means of a contrivance called an air lock. This method can be carried to a depth of about 100 feet. After that the pressure of the air becomes so great that men cannot work without injury to their health, and even loss of life.

As the necessary depth required to reach hard bottom at Poughkeepsie was 130 ft. we were obliged to adopt a third plan, and do all our work under water and without removing the water.

Had there been no mud and clay overlying the hard material, this would have been comparatively easy. We would have sunk a bottomless box or crib of timber, down through the water, until its sides rested on the hard bottom. We would then have placed in concrete, which is an artificial stone which has the property of hardening under water, and becoming a monolithic mass. Once in that condition, the timber box might decay or be removed without impairing the strength of the pier.

But as there was 70 ft. of mud and clay to go through besides 60 ft. of water, we had to modify this plan by making our crib with double sides, and with a double partition through the center. These sides were united by a timber bottom placed at an angle so as to form a cutting edge. We then filled the spaces with gravel to give the necessary weight. We then dredged out the mud and clay with the dredge.

As fast as the clay was removed the crib would slowly sink, and we would continually put new timbers on the top and fill in more gravel. At last the lower cutting edge reached hard bottom, and would go no farther. We then dredged out all the clay remaining inside and then filled the spaces with concrete put down by the mixer.

This was a very efficacious machine. We could with two of them put in 300 to 400 yds. per day, and were able to fill the crib with concrete in less than a month.

We had thus made an artificial island, but its top was 16 ft. below water. We first leveled up the surface of the concrete, by means of divers using submarine armor. We had previously built a great scow or barge, with a bottom of six courses of foot square timber well bolted together. This was floated over the crib, the masonry pier built on it, until its weight gradually sunk it down so that the bottom rested on the crib island. The sides were then removed and the pier built up to 30 ft. above water.

For 100 ft. higher the pier is built of steel columns well braced together. There seems to be no reason why steel is not equally serviceable when placed vertically as horizontally. The saving of weight amounts to from 700 to 800 tons, while the saving of time is still more remarkable. A stone pier 100 ft. high would take four months to build. A steel pier 100 feet high can be erected and secured together in four days. This is one example of the great rapidity of modern methods of construction over those of former times.

The pressure upon the concrete is about six tons per square foot, and it is safe to sustain 100 tons. The piers above water are all made of concrete faced with cut stone. I prefer this kind of masonry to rubble, as being monolithic and much stronger. It can be done more rapidly, and costs no more. The composition is one part of Portland cement to three of sand, which forms a mortar, to which are added six parts broken stone or screened gravel. This kind of masonry was invented by the Romans. The dome of the Pantheon is a monolith, built in this way. It is like a dish cover. It has no joints to be shaken apart by earthquakes. I remember seeing workmen tearing down old buildings in Rome to open the Via Nationale. The mediæval masonry of rubble offered little resistance to the crowbars of the workmen, but when they came to Roman walls of concrete they had to drill, and blast with dynamite.

While on the subject of the Poughkeepsie foundations, it may be interesting to hear a few words about the Hawkesbury River bridge, now building by the Union Bridge Co. in New South Wales, Australia. It is rather a remarkable coincidence that in the same year the same persons should be building bridges on opposite sides of the world, the foundations of both of which are deeper than the skill of man has ever before reached. Poughkeepsie, as we have heard, has its foundation at 130 ft. below tide, Hawkesbury at 175 ft. The method of construction is almost exactly alike in both cases, except that in the one bridge a crib of timber is used to penetrate the mud and clay, and in the Australian bridge tubes of wrought iron plates riveted together and filled with concrete in a similar manner. The dredge is a steam giant, with an arm which he can lengthen to reach down 185 ft. below water, grasp some ten tons of clay in his hand, shorten his arm, lift the clay above the tube, open his hand and drop it in the river outside. This process he repeats about once in every five minutes. All he asks is to be fed with plenty of good coal and water, and he will work all day and night without stopping. I see no reason why, by his aid, we could not put down foundations 500 ft. below water.

The Emperor of Russia awarded the construction of railways and their equipments to American engineers—the Winans, of Baltimore. Since that time I know of no instance of engineering works being awarded to Americans by any foreign government, on account of the superiority of their designs, until the Australian bridge was awarded to us. We had to compete with engineers from this country, from Britain, France, and Germany. There were some sixteen plans submitted in all, varying in price from $1,500,000 to $3,500,000.

A commission of English engineers of the highest standing examined all these designs very carefully, and recommended ours for adoption, on the ground that it was absolutely the best, although not the lowest in cost.

We have put in four out of six foundations successfully, and hope to finish the bridge ready to cross trains by the end of this year.

I wish to add here that, unless this commission of English engineers had shown the utmost spirit of fairness, and had recognized that science knows no national boundaries and is hampered by no tariffs, we never should have been awarded the work.

SUPERSTRUCTURE.

A great advance was made in bridge building when rolled iron was substituted for brick, stone, and wood. An even greater advance was made when the properties of the metal known as "mild steel" became recognized, and it was applied to the construction of bridges. The specification of this quality of steel, which is used in Poughkeepsie bridge, is:

Ultimate strength.....	60,000 to 65,000 lb. per sq. in.
Elastic limit.....	½ of ultimate.
Elongation in 12 inches..	25 per cent.
Reduction of area at point of fracture.....	40 to 50 per cent.

This material can be depended upon for uniformity. It is not "treacherous." That evil quality is confined to a hard steel, having high percentage of carbon, and whose net strength runs from 80,000 to 100,000 lb. per sq. inch. Let those who dare use it for bridges. I am not one of the number.

The Poughkeepsie bridge is proportioned to carry the heaviest coal trains on both tracks at once, drawn by two consolidation engines. A wind pressure of 32 lb. per sq. foot on all exposed surfaces (sufficient to blow trains off the bridge) is provided for.

The maximum strains have a combination of all these pressures:

Maximum tension.....	15,000	lb. per sq. in.
Maximum compression...	14,300	" " " "
Least tension.....	5,700	" " " "
Least compression.....	6,375	" " " "

The strains are proportioned according to the actual ratio between dead and moving loads.

The bridge will be laid with two tracks of 70 lb. steel rails, with Fisher joint, guard timbers, and Latimer guards at each end.

TEMPORARY STAGING AND METHODS OF ERECTION.

Where there is such a great depth of water and mud, and where the height of the bridge above water is so great, temporary staging, such as is used for erecting ordinary spans, becomes very expensive and takes a long time to build.

Hence the use of *cantilever** spans, which are built entirely from above by means of traveling scaffolds, projecting over, and pushed forward day by day. The weights of the scaffold and of the projecting spans of the bridge are prevented from tipping over either by *anchorages* or by the weight of the connecting spans themselves.

The question is sometimes asked if there is a saving of weight in cantilevers. There is not. It is in this case heavier by about 10 per cent. than disconnected spans would have been, but there is a saving of three very costly stagings and of a great deal of time.

It takes from three to four *months* to put up one of these stagings and the steel structure upon it. It takes from three to four *weeks* to put up a cantilever span of greater length.

TRESTLE WORK.

One of the largest and most successful pieces of timber trestle work executed in this country is that designed to support the two fixed spans of the Poughkeepsie bridge which connect the three cantilever spans.

The depth of water is 60 ft., and below that there is a depth of about 70 ft. of soft mud and dirt. The trestle has been designed to be erected on piles, and after erection of the first span, the trestle taken down, and the piles all drawn out of the river. This has been successfully done, and the same piles will be driven again next spring, and the trestle erected upon them, to raise the second span.

The engravings show the general construction of this trestle work, with the traveler used to erect the steel work.

The piles consist of two yellow pine sticks, 65 ft. long, connected by a joint which was specially designed by the accomplished engineer of the dock department of New York, and has been a perfect success.

There are 22 bents, containing 24 piles in each, and the load carried by each pile, including its own weight, and that of trestle, steel work, and traveler, is about nine tons. The distance unsupported extends from low water to about 15 ft. below the river bed, or about 70 ft.

The piles were driven by 30 to 50 blows of a 3 ton hammer falling from 5 to 10 ft. They would sink at least one foot at the last blow. After standing 24 hours, it required from 10 to 20 blows of the 3 ton hammer, falling 10 ft., to break the bond of the mud. This process was used before pulling each pile, which was done with double, sometimes treble falls capable of exerting a force of at least 25 tons. Not the slightest evidence of settlement was seen in this trestle. If there had been any, it would have shown itself by a difficulty in moving the great traveler, which weighs about 90 tons.

It has been found possible to pull at least 90 per cent. of the piles without breakages.

The trestle work itself is built of white hemlock, except the caps, which are of yellow pine, and the longitudinal braces, which are of white pine. It was framed with bolt joints, connecting splices of 2" oak plank, and iron ¾" screw bolts.

It is 500 ft. long, 120 ft. high, above the piled foundation, and 110 feet wide on the base, and 75 ft. wide on top. The traveler is 73 ft. high. The total height from bottom of piles to top of traveler is 340 ft., or about 20 ft. less than the height of Trinity Church steeple, in New York. It has been subjected to some winds strong enough to blow down chimneys, but never has shown the least signs of vibration. Without counting time lost by delays, it is about a three months' job to drive the piles, build staging, erect steel work, take down staging, and draw out the piles. This, however, requires a perfect organization and the best kind of machinery in ample quantities, all of which have been furnished by Ross, Sanford & Baird, the contractors for this work, to the entire satisfaction of the Union Bridge Co.

The general design of this trestle was fixed by mutual consultation with the members of the Union Bridge Co. and Messrs. Ross, Sanford & Baird. The plans were then made in the Buffalo shops, and all the strains from gravity and wind pressure upon all the parts and connections were calculated, and the parts duly proportioned just as if it had been a permanent railway trestle. The approximate quantities of material in this work are:

Timber.....	1,000 M ft. B. m.
Iron bolts ... .200,000 lb.	
Piles, 130, 135 ft. long.....	528

One of the most interesting things connected with this work is the fact that spliced piles, about 18 in. at the butt, carry 9 tons each, at an unsupported length of 70 ft.

* The word cantilever is used in architecture to signify generally a bracket, and more particularly that part of a rafter which projects beyond the wall of a building and supports the overhanging roof. Hence the derivation of the name, *canterillabrum*—the lip of the rafter.

EXPERIMENTS WITH FOUR AND TWO BLADED SCREW PROPELLERS.

AT a recent meeting of the Institution of Naval Architects, a communication as above was read by Mr. J. B. Andreæ.

Three series of experiments were made last year on the Ceram and Flores, two vessels built for the Dutch Indian navy. The first was with a four bladed screw of 9 ft. diameter, 13 ft. pitch, and 30 sq. ft. blade surface; the second with the same screw, but with the two opposite blades removed; the third with a two bladed propeller of the same diameter, but 11 ft. 8 in. pitch, and 17 sq. ft. surface. The vessels each measure 152 ft. in length, 25 ft. 7 in. in width, and 15 ft. 5 in. in depth. The displacement is 566 tons, the immersed midship area is 189 sq. ft., and the wetted surface of the coppered skin 4,875 sq. ft. The engines are triple compound, with cylinders, in the Ceram, of 20 in., 29 in., and 46 in., and in the Flores of 20 in., 28 in., and 46 in. diameter, the stroke in both being 27 in. The boilers are double ended, work at 120 lb. pressure, have 65 sq. ft. grate, and 2,000 sq. ft. heating surface; they are fitted with forced draught, and the Ceram has a closed stoke hold. The vessels are practically the same, and the trials were made under the same conditions of weather and sea. The author presented curves which showed that in the case of the Ceram the removal of two of the blades only resulted in a slight increase in the number of revolutions, so that the loss of one-half of the propelling surface was more than balanced by the gain in friction and other causes. At a speed above 12 knots the vibrations of the two bladed screw of the Ceram became troublesome; but this was less noticeable in the Flores, the propeller of which had less pitch and more surface. From the curves of revolutions and i. h. p. shown by the author, he has composed the following table, showing the i. h. p. by regular intervals, wanted for a certain number of revolutions with the four bladed and the two bladed screw of the Ceram:

1. Revolutions.....	80	90	100	108	116	123	128
2. I.H.P. four bladed propeller.....	200	300	400	500	600	700	800
3. I.H.P. two bladed propeller.....	140	210	300	375	465	545	625
4. Difference between 2 and 3.....	60	90	100	125	135	155	175
5. Difference in percentage of 2.....	30	30	25	25	22	22	22

From the curves of speed and i. h. p. the following table has been deduced, showing the i. h. p. by regular intervals, wanted for a certain speed of the Ceram with the four bladed and the two bladed screw:

1. Speed in knots.....	8·7	9·7	10·6	11·35	12
2. I.H.P. four bladed propeller.....	200	300	400	500	600
3. I.H.P. two bladed propeller.....	180	275	375	480	625
4. Difference between 2 and 3	20	25	25	20	25
5. Difference in percentage of 2. ...	10	8	6	4	4

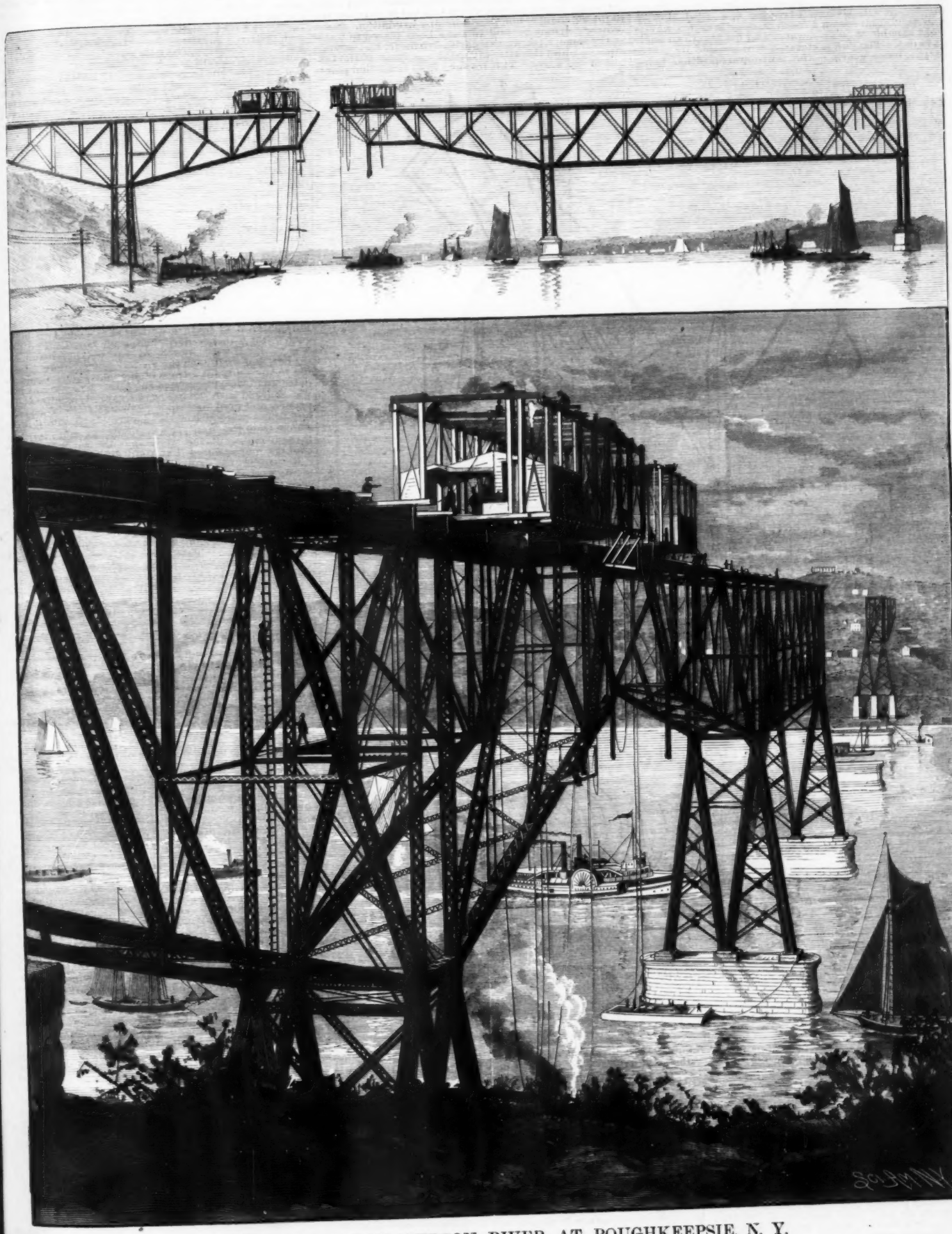
At 11·8 knots speed, the i. h. p. for both screws was the same, viz., 565, and the e. h. p. is then 348.

HARBOR TORPEDOES IN BERMUDA.

AN officer of the Royal Engineers, of the British army, who is stationed at Bermuda, is in town. He has made the rounds of the defenses of New York Harbor, by invitation of various American officers, and very courteously, but plainly, says that we are not fortified at all. "The government of the United States," he said, "is to blame. The government will not spend money upon proper fortifications or guns. There is plenty of engineering ability in the United States army, so far as I have had an opportunity to observe it. If money were supplied, New York would soon be almost impregnable. I was much surprised to find that at Willets Point the engineer officers are more than abreast with the engineer officers of most nations, and that they have improvements that I did not dream were outside of England.

"Our harbor at Bermuda is very differently cared for. Though, of course, an enemy could not do one billionth part of the financial damage over our way that he could in shelling the city of New York, still we regard Bermuda as of great importance strategically. It is a base of supplies for which an enemy operating in this quarter of the world would at once make a struggle.

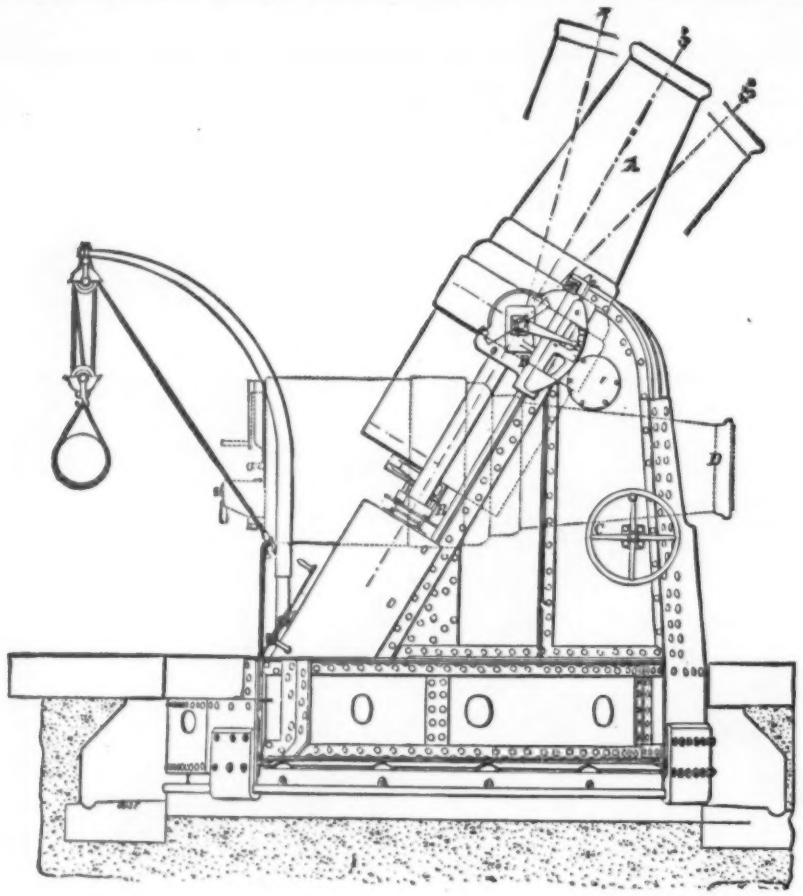
"Our harbor is completely protected by torpedoes. We have careful practice throughout the summer. The torpedoes are sunk and wired in accordance with a permanent plan, and the location of every torpedo is distinctly marked upon a map. Last summer we practiced on an old hulk, and the experiment was very interesting. I sat in our observatory with a map of the harbor before me, and followed the drifting hulk with a telescope. A heavy brass pencil hung from the lower side of the rim of the telescope, and as I turned the telescope in following the hulk's movement, the pencil moved slowly. Just as the hulk was over one of the submerged torpedoes, the pencil touched the key of the battery, and the hulk was blown skyward in rather small pieces. We do not think that an enemy could enter our harbor."—*N. Y. Sun.*

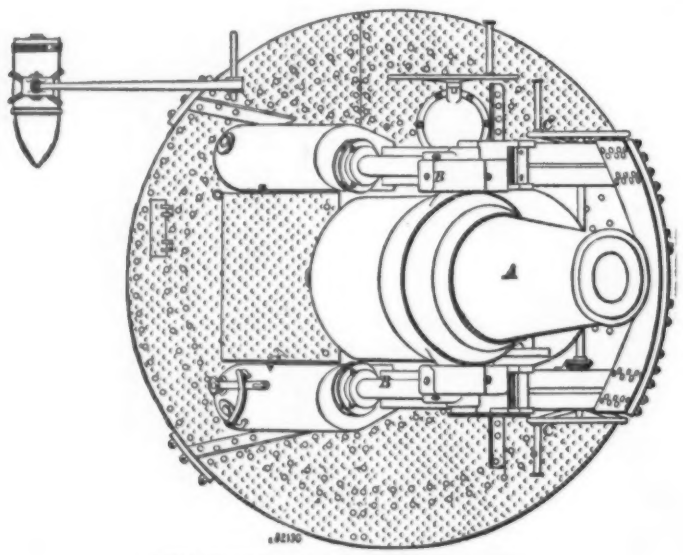


BRIDGE OVER THE HUDSON RIVER AT POUGHKEEPSIE, N. Y.

ELEVEN INCH HOWITZER.

AMONG the various objects forming the splendid exhibit of the Elswick firm at the late Newcastle exhibition, the 28 centimeter high angle firing howitzer, for penetrating the decks of war vessels, and which is one of the latest types of gun produced by this firm, did not find a place. We publish, from *Engineering*, an elevation and plan of it below, and from these the arrangement will be seen to consist of a rifled 11·02 in. howitzer, mounted on a recoil framing in such a way as to be capable of being elevated and fired up to an angle of 75 deg. The gun is elevated or depressed by means of the hand gearing, the horizontal position being





ELEVEN INCH HOWITZER.

shown in dotted lines. The form of mounting is known as the Elswick hydro-pneumatic center pivot system.

CARBO-DYNAMITE.

ADDITIONS continue to be made from time to time to the already lengthy list of explosive compounds for blasting purposes. The most recent addition to that list is carbo-dynamite, which is a remarkably powerful explosive belonging to the nitro-glycerine class. It is the joint invention of Mr. W. F. Reid and Mr. W. D. Borland, and is composed of ninety parts by weight of nitro-glycerine absorbed by ten parts of a variety of carbon, the great porosity of which is indicated by its absorbing power. Nor is the high rate of absorption it possesses its only good mechanical feature; it is also extremely retentive, which adds greatly to its value as an explosive agent.

It possesses several important advantages over ordinary dynamite, which consists of 75 per cent. of nitro-glycerine mixed with 25 per cent. of kieselguhr, which is a porous mineral substance. Kieselguhr being incombustible, it cannot add to the force of the explosion and must be looked upon as an adulterant of the nitro-glycerine, so far as explosive effect is concerned. Carbo-dynamite, on the other hand, not only contains 15 per cent. additional nitro-glycerine, but the absorbent substance, besides acting as a safe carrier for the nitro-glycerine, is itself combustible, and adds to the explosive effect.

The new explosive, therefore, contains 100 per cent. of actual explosive substance, as against the maximum of 75 per cent. of the ordinary dynamite. Carbo-dynamite moreover is not hygroscopic, water apparently having no action upon it. We have seen some of this compound, which was stated to have been immersed in water for nearly six weeks, but which had not undergone the slightest change, nor was there any exudation. Some ordinary dynamite, said to have been placed in water at the same time as the carbo-dynamite, had become dissolved, and the nitro-glycerine was lying at the bottom of the water. This freedom from exudation points to the use of carbo-dynamite in fiery mines. Being unaffected by water, it may be mixed with this liquid in any required proportion.

It is claimed that the large volume of steam generated at the moment of explosion not only extinguishes any flame which might have been produced, but also adds considerably to the effect of the shot. Another important advantage is that, unlike ordinary dynamite, carbo-dynamite used in close headings or mines does not result in the production of fumes of a deleterious nature.

Hence the progress of underground work is not interfered with, nor is the health of the workmen injuriously affected. It is further claimed that the explosive force of the carbo-dynamite can be regulated, that its manufacture is simple and inexpensive, and that its price does not exceed that of ordinary dynamite.

Having stated the nature of carbo-dynamite and pointed out its advantages, we will next proceed to show how amply these advantages—that is, those relating to practical working—were demonstrated by some experiments at which we were present, and which were carried out recently in the presence of a large party of scientific and other gentlemen interested in the use of blasting agents in mining, quarrying, and tunneling.

The experiments were carried out at Treherbert, Rhondda Valley, South Wales, at the instance of the Carbo-Dynamite Syndicate of 20 Great Winchester Street, London, and were conducted by Mr. Reid. In the first experiment a 21 foot length of double headed 80 lb. steel rail was placed on its side on supports 9 inches high and 12 feet apart, and 1¼ oz. of carbo-dynamite was laid on the rail and tamped with clay. The explosion broke the rail in two, cutting out about 9 inches, and embedding the fragments in the earth, the fractures showing a very hard steel. In the next experiment a bore hole 13 inches deep was made with a 1 inch drill in a large bowlder of tough sandstone weighing about 35 cwt. The hole was charged with 2 oz. of ordinary dynamite and fired, the shot splitting the stone up into one large and several smaller pieces. A similar charge of carbo-dynamite was placed in a similar bore hole in a larger stone of the same character, partly embedded in the earth. The explosion shattered the stone to a much greater extent than in the previous case, and on examination it was found to be a denser rock, but it was stratified, and disruption was therefore rendered more easy, so that the new explosive did not have a fair chance.

The deleterious effects of the noxious vapors from ordinary dynamite being well known, the next experiment was made in order to demonstrate the innocuous character of carbo-dynamite in mines and other badly ventilated workings. The visitors were therefore conducted to the heading of a tunnel half a mile in from daylight, where two shots were ultimately fired. This tunnel, which will be two miles long, is being made on the Rhondda and Swansea Bay Railway, now in course of construction, Messrs. S. W. Yockney & Son being the engineers. The contractors are Messrs. W. Jones & Co., by whose permission the next two experiments were carried out.

The tunnel runs through a hard sandstone approaching quartzite in texture, and near the end two holes, each 3 feet 9 inches deep, had been bored. The first was charged with 16 oz. of carbo-dynamite and a primer, and fired. On the visitors immediately returning to the spot, not a trace of noxious fumes could be detected in the smoke from the fuse. The second hole was charged with 16 oz. of ordinary dynamite and a primer, and fired, and upon returning to the spot noxious fumes were distinctly discernible in the powder smoke from the fuse. It was, moreover, considered by those in charge of the work that the carbo-dynamite shot got more ground than the ordinary dynamite.

Returning to daylight, some comparative experiments were made to demonstrate the superior power of carbo-dynamite over ordinary dynamite. Here two lead cylinders were used, each weighing 40 lb. and measuring 8 inches high by 4 inches in diameter, bored with a inch central hole 6 inches deep. In one ¼ oz. of carbo-dynamite was placed and tamped with sand, and in the other a similar charge of ordinary dynamite, similarly tamped. They were both capped and fused and fired, detonators and miners' safety fuse being used throughout the experiments. On examination it was found that the carbo-dynamite cylinder had a spherical expansion around the region of explosion 5⅛ inches in external diameter, while the original capacity of the bore hole, which was equal to 78 cubic centimeters (4·758 cubic inches), had become increased to 590 cubic centimeters (35·99 cubic inches). The external diameter of the ordinary dynamite cylinder measured around the spherical portion was 4¾ inches, and the internal capacity had become increased from 78 cubic centimeters to 347 cubic centimeters (21·167 cubic inches), showing a heavy percentage in favor of the new explosive.

In the next experiment a charge of ¼ oz. of carbo-dynamite was placed in the center of the bore of a hydraulic tube made of the best steel. The tube was 1 foot long, with an external diameter of $1\frac{8}{16}$ inch and an internal diameter of ¼ inch. Both ends of the tube were tamped with sand. A similar charge of ordinary dynamite was placed in a similar tube, tamped in the same way, and both were fired. The carbo-dynamite did its work well, but the ordinary dynamite apparently better. On examination, however, it was found that the metal of the ordinary dynamite tube showed a crystalline fracture, and the experiment was therefore worthless, and was repeated under precisely similar conditions. In the result the ordinary dynamite tube was opened out 3 inches at the widest lateral spread, the tamping being left in both ends. The carbo-dynamite tube opened out to maximum lateral spread of 4⅛ inches, was bent to a considerable angle, blew out all its tamping, made a small crater in the earth at the firing point, and was blown high into the air, falling about 15 yards off. The final experiments consisted in placing 1 oz. each of carbo-dynamite and ordinary dynamite on a flat steel disk 3 inches in diameter and $\frac{5}{16}$ inch thick, supported upon a steel ring or collar. After explosion it was found that the ordinary dynamite had caused a concavity in the steel disk of ¼ inch, while the carbo-dynamite made a concavity $\frac{3}{16}$ inch deep, or $\frac{1}{16}$ inch more than the other, besides embedding its supporting collar deeply in the ground.

Such is the latest of our blasting agents which has been licensed by the home office authorities, and such are the results of the series of trials made with it, which fully substantiated the claims made for it so far as practical work is concerned. The results speak for themselves, and require no comment from us. By the light of the experiments we witnessed with carbo-dynamite, and the general examination we were able so far to make into the subject, we consider it, as a practical mining explosive, the best with which we are acquainted.—*Iron.*

COMPRESSED OIL GAS AND ITS APPLICATIONS.*

By Mr. ARTHUR AYRES, M.I.C.E.

IN considering this system of illumination, its applicability to buoys, isolated beacons, lighthouses, and railway carriages, etc., the author treated it under the primary heads of mode of manufacture, illuminating properties, cost of storage and transit, and in doing so he referred to the early history of oil gas and the patents taken out from time to time in connection with the system. It was stated that in 1825 Faraday contributed a paper to the Royal Society on "New compounds of carbon and hydrogen, and on certain other products obtained during the decomposition of oil by

* Abstract of paper read before the Institution of Civil Engineers, April 10, 1888.

heat." That communication, however, dealt with the chemistry of oil gas. It was mentioned in that paper that 1,000 cubic feet of good gas yielded nearly 1 gallon of hydrocarbon. The gas from which the hydrocarbon was obtained was manufactured by the Portable Gas Company, and was compressed to 30 atmospheres. It was drawn from a gas holder and passed over water into a large and strong receiver, and from it into portable vessels, the principal condensation taking place in the receiver. The oil gas manufactured by the portable gas company was not distilled from shale oil or petroleum, but from other oils and fatty substances, mineral or vegetable. Between the years 1792 and 1883 numerous ingenious patents were taken out for manufacturing and compressing oil gas for lighting and heating purposes. Oil or hydrocarbon gas was the product of heavy petroleum or shale oil once distilled. It had a specific gravity of about 0·840, and flashed at about 220° Fah.

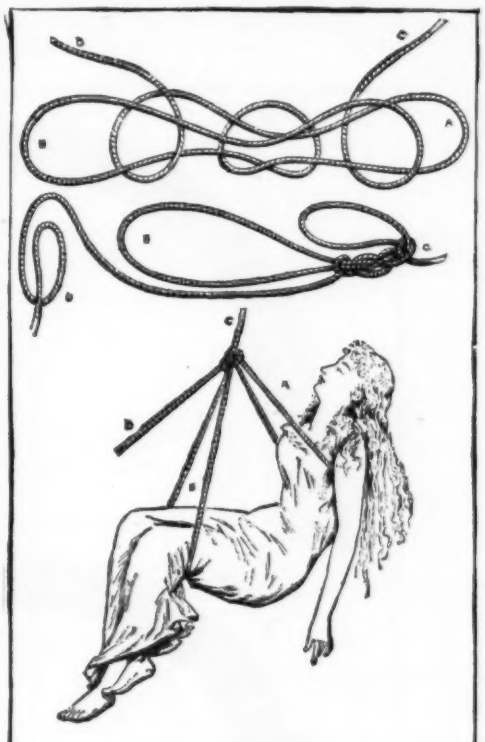
In detailing the process of the manufacture of oil gas the author described the works erected at the South Foreland by Pintsch's Patent Lighting Company. The illuminating intensity of oil gas might be taken at from 40 to 50 candles when burned in a London standard Argand burner, with a consumption of 5 cubic feet per hour, under a pressure of 0·5 inch of water. The price varied from about 5s. 6d. to 16s. per 1,000 cubic feet, being directly influenced by the quantity of gas produced, the management of the retorts, and the price of oil, fuel, and wages. Until the adoption of oil gas for their illumination, buoys and isolated beacons were only useful for the purposes of navigation by day; but they were now equally so by night (in clear weather), enabling vessels to navigate with safety intricate channels, which hitherto could not have been attempted except at considerable risk. Gas buoys, as at present used by the corporation of Trinity House, were constructed of best mild steel; they were spherical, 9 feet in diameter, and surmounted by a light wrought iron superstructure, carrying a lantern inclosing the illuminating apparatus. The total weight of one of these buoys complete was about 80 cwt., the weight of the buoy being 78¾ cwt. and that of the illuminating apparatus 1¼ cwt. The buoys were charged to a pressure of 5 or 6 atmospheres, or from 75 to 90 lb. pressure per square inch. The gas was contained in the spherical portion of the buoy, the capacity of which was about 382 cubic feet, and was consumed at the rate of 0·75 cubic foot per hour, burning night and day continuously. When fully charged to 5 atmospheres and burning at the above rate of consumption, the light would be maintained for 106 nights and days. The intensity of the light was from 17 to 20 candles through the lens. The estimated cost of a first class gas buoy, including the lantern and illuminating apparatus, also royalty, was about £420. In a new form of gas buoy, constructed wholly of mild steel, it was intended to carry the gas in the lower portion of the buoy. The capacity for storage of gas would be 383 cubic feet, which, at a pressure of 5 atmospheres, would sustain the light (consuming 0·75 cubic foot per hour) for 106 nights and days. The advantages of this form of buoy were improved stability and its applicability to the recently adopted uniform system of buoyage. The estimated weight of this buoy was about 6 tons, without moorings.

In 1885, the Canadian government adopted a combination of the bell and gas buoy for service in the Gulf of St. Lawrence, the bell, weighing 3 cwt., giving the usual warning by day and night, supplemented by the light. The gas was stored in a welded cylinder (independent of the buoy proper) having a capacity of 339 cubic feet. The cylinder, when charged to 6 atmospheres, was capable of maintaining the light for 113 nights and days. The weight of the buoy complete was 9½ tons. In 1881 a beacon, lighted automatically by compressed oil gas on Pintsch's system, was adopted by the Clyde Trust commissioners, who had recently erected another on the Gantock Rock, off Dunoon, on the Argyleshire coast, and who were extending this system of illumination at Cardross and Dumbuck lighthouses, Donald's Quay, Rashilee, and Dalmuir light towers. In December, 1885, two iron lighthouses, similar in construction, were erected by the Trinity House, one at Stoneness, opposite Greenhithe, and the other at Broadness, on the Thames estuary. At Stoneness Lindberg's system had been adopted, the burner for producing the light being that of Lyth, of Stockholm. The light burned day and night at full power, showing a white light with short occultation at periods of about five seconds. A description of this system was given. The first cost of Stoneness lighthouse had been £630, and the cost of its annual maintenance was £88. Broadness light was produced by the combustion of compressed oil gas. The intensity of the flashes at Stoneness was about 60 candles, and at Broadness about 500 candles. The first cost of Broadness lighthouse had been £1,026, and the cost of its annual maintenance was £128. Both Broadness and Stoneness lighthouses were under the charge of a boatman, who visited them at least twice a week, when he adjusted and cleaned the apparatus. These systems being comparatively new, no reliable comparison had yet been made as to their relative efficiency. An important installation of an oil gas apparatus for lighting and fog signaling had recently been made by the Commissioners of Northern Lighthouses at Ailsa Craig, on the Firth of Clyde, the first cost of which had been £24,000, while the cost of its annual maintenance was £725. There were now two hundred and fourteen buoys, lightships, beacons, and other lights in use in various countries on Pintsch's system.

The author next dealt with the application of compressed oil gas to the lighting of railway carriages, which he stated was one of growing importance. It was probably first tried in the year 1871 with satisfactory results in Germany, on the Lower Silesian Railway, and in England in 1878 on the St. John's Wood trains of the Metropolitan Railway, with equally satisfactory results. The Great Eastern Railway Company was the next to adopt it, the Metropolitan Railway Company definitely adopted it for the whole of its rolling stock a few weeks later, and other companies quickly followed suit. The systems chosen were those of Messrs. Pintsch and Messrs. Pope & Sons, which differed but little from each other. Some trials were also made of Messrs. Bower's system on the Great Northern Railway. The gas holders were attached either to the roof or to the under-framing of the carriages, and were charged to a pressure of from six to eight atmospheres. The gas was conveyed to the roof lamps by pipes from the gas holders, passing through a contrivance for regulating the pressure at the burners, one such regulator being attached to each carriage. There were now twenty-three thousand four hundred and ninety-nine carriages so illuminated on Pintsch's system, and two thousand seven hundred and ninety-one on Pope's system. Taking the double journey between Euston and Aberdeen, the cost of compressed oil gas was 0·0404d. per lamp per hour, and for the ordinary oil system 0·385d. per lamp per hour, showing a greater cost of the ordinary oil system of 0·3446d. per lamp per hour, or eight and a half times more than oil gas.

LIFE LINE SLING.

THIS sling was first introduced by the London (Eng.) fire brigade, and with that organization, which is composed entirely of sailors, it became in their hands a most valuable adjunct to their life-saving appliances. It is there known as the chair knot, and the accompanying description and illustrations will explain the formation of the knot, the knot when hardened up and ready for use, and the knot in use.



THE LIFE LINE SLING.

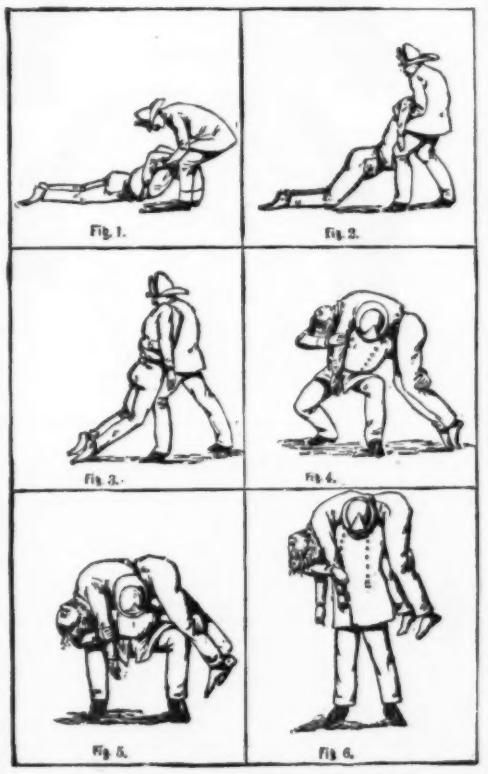
The sling may be formed in the middle or toward any end of a rope, and consists of two loops or bights of a combined length (for a grown-up person) of about 6 ft., one about 3½ ft. and the other about 3½ feet ft., with the knotted part between them, and the hauling part and the guy both leading from the knot. It may be formed in a variety of ways, one of the simplest and quickest of which is as follows:

On that part of the rope which is to be used, put up a common double over-hand knot, hauling the bights through to about the length before mentioned, and measuring the whole length by the ordinary span of the arms. Then over each bight pass a half inch of the rope, and slip the hitch close down to the knot; use one end for the hauling part and the other for the guy.

The sling does not require the use of an end in forming it; it uses very little of the rope; it can be formed in a moment; and will never, under any circumstances, render. To adjust the life sling on a person to be rescued, slip both loops over the shoulders and arms; let the longer loop come into the bend at the back of the knees, the smaller loop close up under the arms, the face and guy in front of the chest. Be strong, active, quick, fearless, and intelligent; but above all, be resolute.

Always give precedence to women and children in rescuing lives.

When an insensible person is found, turn them face downward, and take a hold close up under each armpit, Fig. 1; then raise the body as high as it can be lifted in that position, and allow it to rest on one of the knees, Fig. 2; then shift the arms around the waist, and, after interlocking the hands, lift the person in an upright position, Fig. 3. After this, take hold of one of the wrists with one hand, and drop to either right or left into a stooping position, Fig. 4; at the same time pass the arm that is free between or around the legs, and the person will then fall across the shoulders, Figs. 5 & 6; then rise in an upright position, and balance the body well on both shoulders. In this manner, carry the person down stairs, to the roof, or to the window. If a canvas chute is used, raise the feet to the mouth of the chute with one arm; then take hold of one of the wrists, and ease the body gently off the shoulders into the chute, always taking care to keep the face uppermost. As a rule women should be sent down head first, but if feet first it is well to tie a small line around their clothing to prevent its possibility of being caught in the chute.—*Fireman's Drill and Manual.*



RESCUING INSENSIBLE PERSONS.

A NEW WAY OF UTILIZING AMMONIA LIQUOR.*

By C. J. R. HUMPHREYS, of Lawrence, Mass.

THE gas manager of the present day finds himself in a rather unique position, in that the cost of coal, as well as many other articles which go to make up the gross cost of gas manufacture, are steadily and surely increasing; and in like manner there grows a demand on the part of the public for cheaper gas—a demand which is often pressed home by our new friend, or rival (call it which you may), the electric light. The two growths do not blend well together; on the contrary, they are decidedly antagonistic, and present to the gas manager a very complex problem—a problem, however, which it is not the purpose of the present paper to attempt to solve. Suffice it here to remark that the proposition, in very many cases, can only be worked out by the help of the by-products of gas making—coke, tar, and ammonia.

Of these three residuals, coke and tar will generally take care of themselves, though possibly we should except the very large gas works; for if the demand for coke grows slack, we generally find an obliging body of coal miners or other laborers will strike, and thus, by raising the price of coal, increase the demand for coke. In most cases the tar trade can be worked up by the aid of the sidewalk makers; and we are left with the remaining residual, ammonia water, to dispose of. And here we find that means of increasing our revenue from this source do not so readily present themselves.

True, in the case of the most extensive gas works, the quantity of ammonia liquor for sale is so large as to warrant the erection of ammonia works in the vicinity of the gas house, either by the company themselves or by an outside party; but it is not gas works of the first magnitude that we are very much interested in. What more particularly concerns us are the small and medium sized undertakings; and here we find the disposal of ammonia water at a figure which, after deducting freightage, will net the seller any appreciable return is, indeed, a difficult task. The trouble is apparent. The ammonia works are generally found near the largest gas works; hence the smaller concerns, situated at a distance from the large centers, have to pay for transporting the liquor many miles. When it is remembered that in ordinary gas liquor of, say, 10 oz. strength the weight of the contained ammonia bears but a small relation to the weight of the liquor, it is clear that the sulphate or *aqua* maker cannot afford to pay such a sum for this product as will, after deducting the expenses involved in handling and transporting for a considerable distance the ammonia and the useless water, return to the gas maker any considerable revenue.

One proposed solution of the problem is that the gas companies should erect sulphate works within their own inclosure, and either sell the product in their immediate vicinity or send it to the larger centers. But it has generally been found in this country that the running of a sulphate works by a medium sized gas works is an undertaking of uncertain profit but certain trouble. Consequently, for gas works of moderate pretensions, we are forced to find some way that the ammonia water can be so concentrated that the weight of the liquid shall not bear an undue relation to the weight of the contained ammonia. If we get the liquor to a strength of 70 oz. or 80 oz., we approximate the solution of the difficulty. Obviously, we cannot produce a liquor of so concentrated a form in the apparatus used for purifying the gas; so we must get it to the desired condition by some other means.

At the Lawrence gas works we have recently erected a plant which seems to "fill the bill" very well. It was put up by Mr. Page, to whom we all, I think, are greatly indebted for having done so much to increase the value of ammonia water in this country; and the *rationale* of the system is that the ammoniacal liquor of ordinary strength is distilled in an iron tank by steam heat, and the ammonia condensed in a more concentrated form, so that the amount of this product which is contained in 1,000 gallons of the ordinary

* A paper read at the eighteenth annual meeting of the New England Association of Gas Engineers.

liquor is brought down to a compass of about 150 gallons. The apparatus consists of a series of three boiler-like tanks or stills and several condensing boxes; the stills being set in mason work, side by side, with the smallest one elevated between them. The first tank or still, which is 5 feet in diameter and 9 feet long, contains a steam coil; the next still is 4 feet in diameter and 5½ feet long; while the smallest one is 2½ feet by 4 feet. Surmounting these is a column or washer 2 feet in diameter by 3½ feet high. The condensing troughs are about 13 feet long, 1 foot high, and about 15 inches wide. These troughs contain a double row of 4 inch wrought iron pipes, through which the ammonia vapor flows until the cold water running through the troughs condenses the vapor to a very strong solution of ammonia water. From the last of these troughs the ammonia goes to an iron tank, 2 feet by 3 feet; and from there passes to a small receiving tank set on the floor of the building. When this is filled, the liquid is allowed to run to the large receiving tank (being an iron boiler shell, holding about 4,500 gallons) placed outside the building.

At the commencement of a run, the largest still is about two-thirds filled with the weak liquor. Steam is then admitted to the coil; and the ammonia, with some steam, is driven over into the second still, thence to the third one. Here the temperature is such that some of the steam accompanying the ammonia is condensed.

The ammonia then passes to the column or washer, when the condensation is continued; and the operation is completed in the three troughs by the cold water which is constantly running through these vessels. The whole lay-out of the apparatus is such that the ammonia will be condensed gradually; for were the work performed rapidly, trouble would doubtless be occasioned by the crystallization of the ammonia. The operation is continued for about eight hours, or until the liquor in the first still is reduced to ½ oz. strength or less. The concentrated liquor is stored in an underground iron tank till such time as sufficient accumulates to fill a tank car, when it is pumped to the car on the gas works side track.

As we have laid out the apparatus at Lawrence, we are able to run very economically. The two agents used in the operation are steam and water—the former to distill off the ammonia, the latter to cool the vapor; and our arrangements are such that the water used in the troughs, after doing its work, is allowed to run into a leaky gas holder tank, and the condensed steam, as it passes from the still, is led to a small tank over the sink used by the retort house men for washing—thus giving the men a constant supply of hot water. The overflow from the tank is connected with the pipe which carries off the water from the troughs; so that the water from this point also finds its way to the gas holder tank. If the water is not needed in the tank, it can be used for quenching the hot coke. Thus the only expense to us in running the plant is the fuel used in making the steam and the wages of the boy who takes care of the apparatus. The former item is not large with us, as we use breeze and cinders for fuel. The labor item is not heavy, as the boy also looks after the concentrator, and runs the exhausters and the "Standard" washer, as well as keeps some of the memorandum books of the works. I am now considering the advisability of running the condensed steam to a large tank and pumping it back to the boiler before it has a chance to cool off.

In order to arrive at an estimate of the amount of steam which the concentrator requires, I recently made a test by measuring the condensed steam resulting from an eight hours' run. Knowing that a much larger quantity of steam is required at the earlier stages of the run, I caused the condensed steam to be collected at the end of each half hour, with the following results:

Table showing the Gallons of Condensed Steam saved during each Half Hour, Feb. 6, 1888.

Half Hour.	Gallons of Condensed Steam.	Half Hour.	Gallons of Condensed Steam.
1	35	10	21
2	70	11	21
3	59	12	21
4	24	13	17½
5	21	14	17½
6	21	15	17½
7	21	16	17½
8	21		
9	21	Total	427

From this it will be seen that the run required the evaporation of 427 gallons of water, or 3,558 lb. To evaporate this quantity of water, we require about 600 lb. of breeze. This, at the price at which we sell it, would net us about 15c. Consequently, this sum would represent to us the cost of the steam used in a run; for, as before noted, the water from which the steam is generated is made use of after being condensed back to water. The further details of the run, to which the foregoing figures relate, are as follows:

Quantity of weak liquor used	1,000 gals.
Strength of same	10 oz.
Quantity of concentrated liquor obtained from above	142 gals.
Strength of same	64 oz.

It will be noted that the strength of the strong liquor on the day during which the above test was made was only 64 oz. This was considerably below what we had been running at. The previous day the lad had run the liquor above 90 oz.; and, as a result, had a stoppage in one of the pipes, from the crystallization of the ammonia. I cautioned him against running so high; hence, on the day of the test, in his endeavor to work within my instructions, he had run down lower than necessary. We try to keep the concentrated liquor at about 80 oz.

The effectual manner in which this scheme meets the transportation problem alluded to at the outset of this paper is indicated by these figures, which show that the ammonia contained in 1,000 gallons is compressed into a space of 142 gallons; or, instead of transporting 8,715 lb., we convey only 1,570 lb. The apparatus gives us very little trouble; and while we have not had sufficient experience with it to know yet just what the result in dollars and cents will be, still we are confident that it will bring in a good return on the investment.

[Continued from SUPPLEMENT, No. 634, p. 10130.]

ELEMENTS OF ARCHITECTURAL DESIGN.*

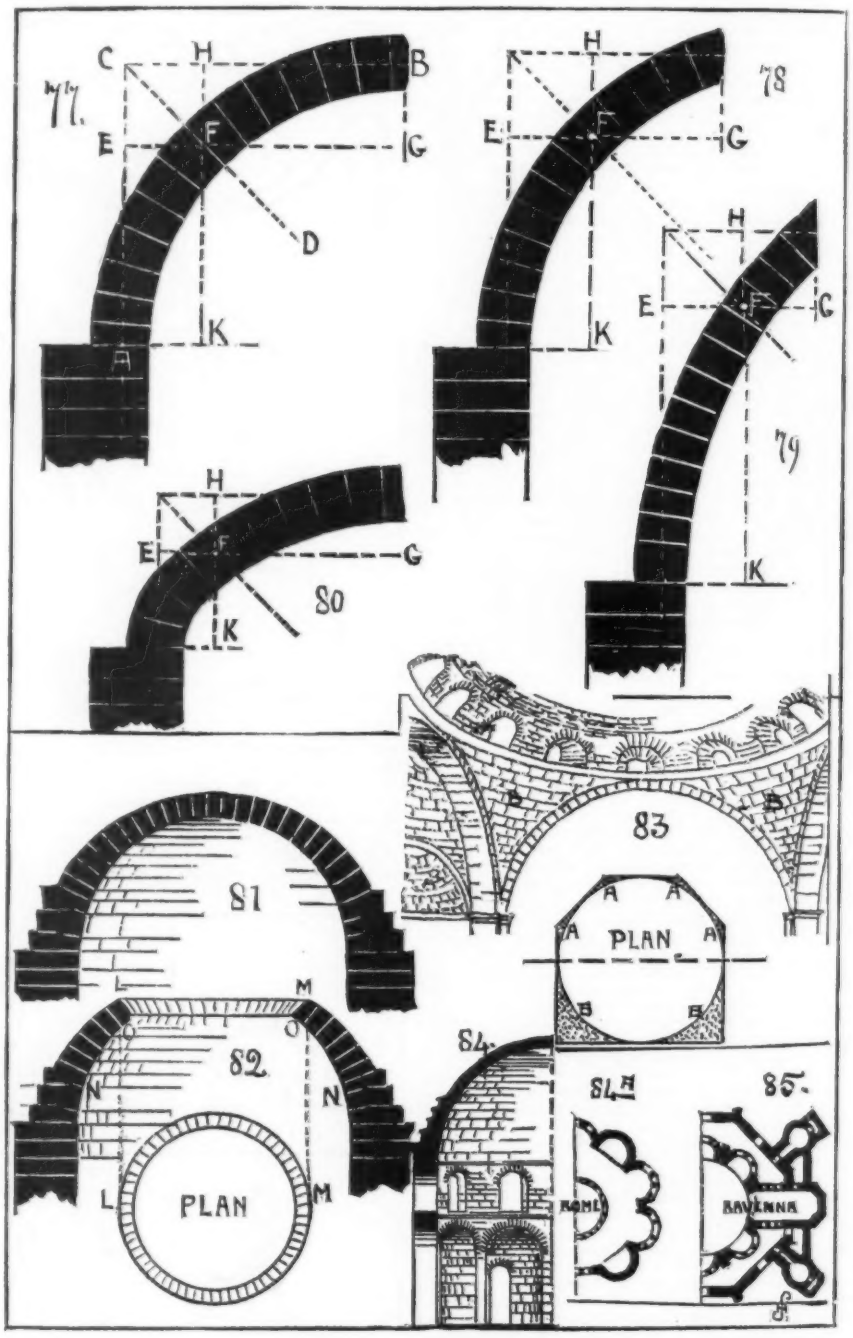
By H. H. STATHAM.

III.

IN the last lecture we considered some of the principal forms of architectural design as dealing with and as influenced by the constructive principle of the beam. We are now to consider it as influenced by the constructive principle of the arch.

Put in the simplest language, the arch may be described as a method of supporting materials above a void, or making them support each other, by their mutual compression; by jamming them together, so to speak, so that they cannot fall into or through the space below them. We may begin with two stones tilted against each other so as to meet in the middle, like our two rafters in Fig. 37 (Lecture II.); and it is obvious that here they cannot fall so long as the walls remain immovable. If we want to bridge over a wider space than the two stones will cross leaning against each other, we may insert a third stone horizontally between the upper ends of the two leaning or rafter-like stones, and these two will support the third one between them as long as the walls against which they are abutted remain immovable. Here we have made an important step toward the principle of the arch; and it is easy to imagine the principle carried further by little and little, until a large number of stones are supporting each other in the same manner over a void space narrower than the combined length of such stones if they were set out in a straight line, and which space therefore they cannot fall through so long as they are accurately fitted together, and, once more be it noted, so long as the walls which form their *abutment* remain unmoved.

The conditions of stability are, however, much more complicated when we come to consider an arch of many stones than in the primitive form of two leaning stones and a horizontal one supported between them, which has been suggested as a first and simplest form of the arch. In this primitive case the pressures are very simple and easily calculated; in the case of an arch of many stones the pressures are very complex, nor in fact is there any quite decisive or authoritative theory, to the present day, as to the manner in which the pressures in an arch should be regarded. This want of certainty and unanimity as to theory is no doubt partly owing to the much greater difficulty of making and recording test experiments on the strength and the method of failure of arches as compared with beams. The formulæ for the strength of beams, both wood and iron, in resistance to various strains, are now in a tolerably complete stage; the weights they will bear can be pretty certainly calculated, the manner in which they usually fail is known; but the theory in this case is the result of many series of experiments, which it is easy to make with beams. A beam breaks under test at some one point, and when broken the two portions are still there to be practically examined; or it deflects to a certain extent, and its deflection, and the amount of "set" which it takes,* can be accurately measured. But an arch must be experimented on under much less favorable conditions for observation. Being of rigid and not of elastic materials, it does not give way gradually, but by a sudden crushing at one or another point, the behavior of which must be watched at the moment; and when the arch has parted and fallen under its test, it has gone altogether as an arch; it is in fragments, and is of no use for further comparison or investigation as to its manner of failing. Rondelet's experiments are the most complete and important that have been made, and from them and other observations conclusions have been deduced which it is sufficient to state briefly and generally here, as we are mainly concerned here with the influence of the arch architecturally.



There is one difference in principle between our supposed primitive arch of three stones and the true arch, viz., that it is contrary to the principle of the true arch that the stones comprising it should be longer in the direction in the curve of the arch than in the direction of its thickness. The wedge shaped stones (called *voussoirs*) composing a true arch act at certain points or under partial pressures like levers, one tending to thrust another round; and they have the more tendency to do this in proportion as they are long-shaped in the direction of the arch. And as the whole of the voussoirs composing an arch are in a state of compression one against another, it can easily be seen that pieces of material in compression, even apart from any arrangement in the arch form, are much more stable when subjected to compression on their sides than against their ends. Take three cubes like what are put in toy boxes of bricks, an inch

* Delivered before the Society of Arts, London, December 12, 1887. From the *Journal* of the Society.

* "Set" is the term applied to a permanent deflection in a beam from which it does not recover.

square and say six inches long, lay them one over the other on their sides, and they will sustain without any disturbance of their position any weight up to their crushing point; but place them on each other end to end vertically, and a very small irregularity in the pressure will overturn their equilibrium; one will turn on the end of another, and the whole will come down. The whole of the pieces composing an arch are in a state of resistance to compression, and the flatter they are (within certain limits) in the direction at right angles to the line of thrust, the less likely they are to turn one upon another as on a fulcrum.

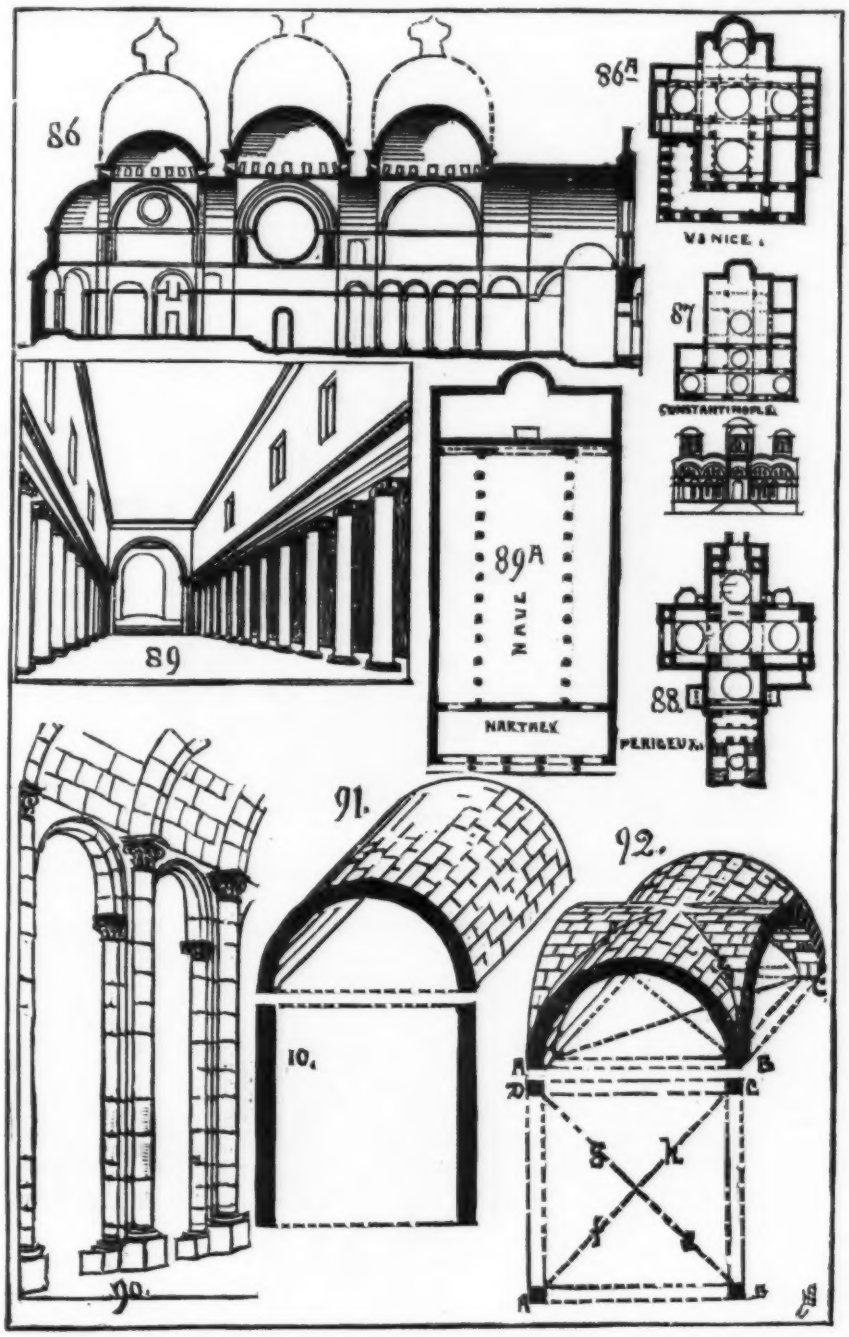
The typical form of arch therefore is that shown on Fig. 77, the half arch only being shown, whatever applies to the one half applying to the other, if we suppose it to be equally loaded. The voussoirs are wedge-shaped, with joints radiating from the center from which the arch is struck, because only so can all their bearing surfaces be brought into contact; and they are deeper in the joint than on the *intrados* and *extrados*,* for the reason just given in the last paragraph. Now, the arch as shown there is a series of wedge-shaped pieces held up across a void by being jammed together; they need not necessarily be arranged in the form of a semicircle; they might be arranged in an ellipse (as at Fig. 80), or in a catenary curve (the reverse of the curve formed by a suspended chain with its links free to move on one another), or in several other curves; but it is important that they should be arranged in a symmetrical curve of some kind, not only for appearance, but for securing an even balance of pressures; and the circle, or segment of it, has been most used in the world's building work, as the easiest and simplest to construct. Now, inasmuch as the stones forming the upper portion of the arch, and whatever is built upon them, have a definite weight, with nothing immediately under to support it, it is clear that weight must go somewhere; it is in fact transformed into an oblique thrust acting against the lower portion of the arch and tending to thrust out the arch and the wall which carries it. It will thus be seen what an important difference there is between the arch and the lintel in their effect on the substructures. The lintel, as we saw, exercises nothing but one simple vertical pressure on what is below it; the arch is constantly exercising an outward thrust upon the walls, tending to push them apart and to drop in between them itself; and this fact of the outward thrust of the arch was the main originating factor of what is known as the Gothic style of architecture, the greatest and most complete arched style of the world.

In estimating the extent and direction of this outward thrust of the arch, the old school of theorists used to consider the arch as built without mortar, and composed of voussoirs infinitely smooth on surface and exercising no friction upon one another, so that the question was simply one of equilibrium of pressures. But this theory has been dropped in modern times as being too far apart from the real facts of the case; for even if we leave the cementing materials out of account (as we perhaps ought), the friction of the voussoirs on one another is unquestionably a very important factor in the stability of the arch. The cementing material is practically an important one also, so much so that it is related of Brunel that when an arch which he had built fell down, instead of reconsidering the stability of its lines, he gave orders to build it up again in cement. But, in theory, cementing materials are only an additional safeguard against disturbance, not an element in the construction. But the friction of materials is a recognized power in engineering science, which has tabulated the slopes and angles at which different materials will retain their position by the action of friction as opposed to gravitation; and for stone as usually worked for building purposes the angle is about 30°. In Fig. 77 the upper joint at the fifth voussoir (from the springing of the arch) is at that angle, therefore we may take it the voussoir next above that joint would be just in a state of equilibrium between the action of gravitation and that of friction, or the arch up to the sixth joint (next joint below F) would remain in the position in which it was placed, overhanging and just ready to fall, but retained by the friction of the voussoirs on one another. If another voussoir is added, it then would fall in, unless met by an opposing force tending to keep it in its place; and such a force is represented by the upper portion of the arch, which directs a pressure outward from the center to the side, counteracting the pressure inward at the lower voussoirs. We may now, with at all events approximate truth, state the condition of the arch in this manner: Both portions of the arch, that below and that above F in Fig. 77, exercise both a vertical and a horizontal force. The vertical force in each portion represents the weight of the materials and of whatever superstructure may be placed upon the arch; the horizontal forces represent in the lower portion, A F, a tendency to fall inward, and in the upper portion, B F, a tendency to thrust outward, and a diagram approximately representing these opposing forces may be constructed in this manner. Taking the mean line of the lower portion, A, produce it vertically till it meets, at C, the mean line of the upper portion produced horizontally from B; then bisect the angle by the line C F D, and draw E F G horizontally through F, and K F H vertically through F. The parallelogram H B F G may then be taken to represent the combined vertical and horizontal pressures of the portion F B of the arch, H F representing the vertical pressure, and F G the horizontal pressure; and similarly the parallelogram A E F K may be taken as representing the vertical and horizontal pressures of the lower portion A F of the arch, E F being the horizontal pressure (inward) and F K the vertical pressure. Thus it will be seen that the horizontal pressure is much the greatest in the upper half of the arch, a great part of the weight of this portion being transformed into an outward thrust, while in the lower portion the vertical pressure is the greatest, a great part of this lower portion of the arch pressing nearly vertically on the walls. Consequently it will be seen that in a semicircular arch the greatest outward thrust is at a point about half-way between the crown and the springing of the arch; and this theory is in accordance with observed fact. When an arch of this shape gives way through being overweighted, it does so by rising at or about the part F, the lower portion being thrust outward (at F), and the crown simultaneously sinking (at B). If we take a different form, a moderately pointed arch (Fig. 78), the point, F, is relatively higher, and the horizontal pressure, F G, is proportionately smaller; point the arch still more (Fig. 79) and we have E F and F G similar, and this arch has practically no thrust, the inward and outward pressures being balanced. Take an opposite form, a low elliptical arch (Fig. 80), and we find the horizontal thrust of the upper portion (F G) greatly increased, and the inward thrust of the lower portion (E F) diminished, and its vertical pressure (F K) diminished also, so that this is an arch requiring a great deal of abutment to resist its spreading tendency.

In a semicircular arch, as at Fig. 77, the line of pressure tends outward toward the extrados of the arch as we descend toward the springing, owing to the accumulating weight and pressure of the voussoirs above, and if the line of pressure gets outside the extrados, the arch is unstable and is nearly sure to give at that point, so that the arch in Fig. 77, if we suppose it to be stable as drawn there, would become unstable if the voussoirs were materially reduced in depth; and an arch such as this, if standing free, would require to be thickened toward the springing, as in the dome section shown at Fig. 81, which practically amounts to raising the line of wall and raising the real springing of the arch to a higher point. In practice, however, such an arch as Fig. 77 is almost always built in a solid wall, and is filled up solid above the extrados; and in this case, if we suppose that arch with a solid wall over it as high as the crown of the extrados, the vertical weight of the wall above the haunches would be sufficient to counteract the outward thrust tending to make it rise at F; but there would still be some remnant of outward thrust left at the springing, and we must see that our vertical wall which supports the arch is strong and massive enough to resist this spreading tendency. If we suppose this arch to be prolonged along the whole length of a building in the form of a tunnel, we should then be obliged to build a very thick wall along the whole length of the building to resist the thrust of the arch. A roof so built, a single prolonged arch, is what is called a "wagon vault;" it is the simplest manner of vaulting a building, but it is a construction very wasteful of materials in consequence of the continuously thick walls which are required to carry it. How this is to be obviated, and the wall supports economized, we shall see just now when we come to speak of the vault.

But before going further, let us pause to point out why we have always spoken all along of stone as the material to be employed, and why the arch is so peculiarly a *masonic* form of building. In speaking of the Greek lintel, it was observed that this employment of stone as a horizontal beam resting on two points of support is the weakest way in which stone can be employed. It is subjected to a strain tending to break it across, and stone being a granular material, with no fibrous cohesion in its parts, is more easily broken in this way than in any other, more easily even than by tension, since there is a greater leverage exercised to break it.* But such a material as stone is strongest in its resistance to compression; in other words, it requires much greater force to crush it than to rend it, and in the arch the voussoirs are all subject to compression, and to compression only; and hence the arch is in an especial sense the form of building suitable for stone. Wood has much less resistance to compression than stone (most woods at least), and is in other ways less desirable; iron could be employed in arch building, but it would be much more costly than stone, much heavier, and it can be used in a much more economical and suitable manner in the girder form. The arch is the form for stone building; and it has this great practical advantage also over the trabeated style, for stone, that it does not presuppose the use of large blocks. In a beam style a small space is bridged by one large block (if we are confined to stone); in an arch style a large space is bridged by many small blocks.

We have just referred to the wagon vault as a form in which the arch presses equally on the wall along its whole length; before turning to other forms of vaulting, let us glance at another form of arch which also presses on the whole of its substructure wall, but under very different conditions, viz., the dome. This form of covering is that which would be formed if we suppose the half arch, Fig. 77, to be turned round in a complete circle on B as its axis; it is an arch both ways, so to speak, its vertical section being a semicircle (usually) and its horizontal section a complete circle. This fact



* The intrados is the line formed by the lower faces of the voussoirs; the extrados, that formed by their upper faces.

* The difficulty into which construction may be brought in the endeavor to use a comparatively coarse-grained stone in this manner is illustrated in the big Doric portico—not without a certain illogical grandeur of its own—which was put up as the entrance to Euston Station, at a period when it was supposed that everything was to be Greek. Here the scale of the Doric order employed was so large that monolith stones could not be obtained easily which would carry across the openings, and so the architraves are actually in two stones welded together by iron cramps. It would be difficult to find a more pointed *reductio ad absurdum* of the fallacy of employing a style quite independently of, or in contradiction to, the mechanical capabilities of the material in which it has to be built.

of its being composed of rings of horizontal arches or circles puts it under very different conditions from the arch; for when once a circle of the dome is completed horizontally, it cannot fall in. A dome may be built half way up and then left as in Fig. 82; and while an arch left in that unfinished stage would fall in, not having the upper portion to oppose it, the dome so left cannot fall in, because, as will be seen from the plan of the upper ring beneath, Fig. 82, that upper ring is itself a horizontal arch, formed of stones which are wedge-shaped horizontally (as well as vertically). Hence a dome, though generally made of the section of a semicircular arch, for reasons of appearance, may be built in many forms of section in which an arch would not stand for a moment; it may even be built with the lower portion in a reversed curve convex to the interior, which would in fact be a very strong section, as it would exactly follow the line of pressure, which tends outward toward the base of the dome, as toward the base of the arch. It has generally been felt, however, that the architectural grandeur of the dome is best realized in its simplest form of a perfect hemisphere, or such a shape at least as would make a perfect hemisphere to the eye; for there is much distortion of effect to be allowed for in looking up at a dome internally. When a circular dome is placed on a circular substructure, as in Figs. 84 and 85, the problem is an easy one; or when it is placed on an octagonal substructure, as indicated in the upper portion of the plan below Fig. 83, it will be seen that the octagon approaches so nearly to the circle as to leave only a little difference in plan to be adjusted by corbeling out * the walls till they meet the circle. But where the dome has to be built over a square, as indicated on the lower side of plan, Fig. 83, there remain two large angles to be filled up at B B (plan and sketch, Fig. 83). These portions, which are called pendentives, have been the scene of many interesting experiments in architectural design. The constructive principle in treating them may be resolved into two methods: that in which the space B is really a segment of a dome abutting against the extrados of two of the main arches as shown in Fig. 83 (which is a sketch of the domical construction of St. Sophia, at Constantinople), or that in which the pendentive is corbeled out or carried on an oblique arch thrown across the angle above the springing of the main arches. The corbeling out principle cannot be very well employed in this position except when the building is on rather a small scale; when it is apparently employed for effect, it would often be found that the structure is really domical; and there is no doubt that the domical treatment of the pendentive is the right one architecturally, because we are thus employing a homogeneous system of construction in every part of the building. In such a building as St. Sophia, where every portion is treated domically, we have the same system of architectural consistency as we find in the Greek style, where every space is covered by a lintel, and in the Gothic, where every one is covered by a pointed arch.

A good deal has lately been said in regard to the decorative treatment of the interior of the dome, in relation to the experiments in that direction made on the dome of St. Paul's. The subject is one of great interest, for there is no doubt that the interior surface of a great dome is one of the grandest and most suggestive positions that could be imagined for decorative treatment, but it appears to me that there are two mistakes which have operated to the prejudice of many of the dome decorative schemes that have been tried. One is the attempt to paint figure subjects on a dome illustrating a special history. No one can ever see these properly, and they are thrown away in such a position; any figures that are introduced should be of a simple and purely decorative character, with no attempt at giving special expression or meaning to them. This can never be appreciated in a dome of first class dimensions and height, unless the figures are on so large a scale that they must in that case have the very serious drawback of dwarfing the whole scale of the architecture.

Dome decoration, again, should never be so strong in color as to bring down the apparent height of the dome. It may have a most disastrous effect in this respect. One object of any decorative treatment should be to assist the soaring effect of a dome interior, not to lower it. The other point in which I think mistakes have often been made has been in dividing a dome for decoration into vertical sections, as Thornhill did in St. Paul's, and as was proposed to be done in the new scheme. This is contradicting the constructive character of a dome, which is a homogeneous semi-spherical vault, not a collocation of vertical arches. The arrangement undoubtedly renders the task of the decorator much easier, by dividing up his work into more manageable sections; but it is destroying the essential grandeur of the domical form; and any decoration which is applied to it should be on a scheme embracing the whole domical surface in one continuous design.

The dome is perhaps, in its finest aspect, more an internal than an external feature; notably so in St. Sophia, the great typical domed church, where externally the dome is hardly seen; and it is exceedingly difficult to treat a dome with equal effect internally and externally, as the treatment most effective in the one case is least effective in the other. Externally a dome is a feature whose lines are always tending away from the eyes; consequently, except from a great distance, it always seems lower than it really is in comparison with the rest of the building. Every one knows how the dome of St. Peter's disappears as you approach the west front, sinking into the building;† and on the other hand, if the dome is raised sufficiently to make a lofty center to the composition externally, the result is that internally it is too lofty for effect; it loses its apparent size through the perspective diminution. Wren attempted to get over this difficulty in St. Paul's by making two domes, a timber and leaded one to show externally, and the real masonry dome to show internally; he has succeeded, there is no doubt, in producing a good effect both externally and internally, but it is at the expense of architectural and constructive truth.

Another anomaly in St. Paul's, the construction of the lantern that crowns the apparent dome externally, reminds us of another constructive point in which the dome differs from the arch. The latter is generally built up solid above the extrados, with a weight on the haunches. The dome, when made an external as well as an internal feature, cannot have any load on the haunches. Consequently it is a very weak form to carry any weight on the crown, which would naturally (as shown in speaking of the arch) cause the haunches to rise; and hence the difficulty of planting any important crowning feature on a dome. In the Florence cupola, Brunelleschi was so conscious of this that he made the cupola of a pointed section, the better to support the big lantern which he intended to mount upon it, and he also placed a tie round it at the haunches. It is true Brunelleschi's cupola, though often spoken of as a dome, is not a real dome; it is an octagonal cupola formed of eight arched gores meeting at the apex; but the treatment as to the carrying of the cupola would have been equally right if it had been a dome.

In St. Peter's, the dome did begin to fail at the haunches in consequence chiefly of the weight of the lantern; and it had to be bandaged up with a chain (just where Brunelleschi had put his) to prevent further mischief. In St. Paul's, Wren evaded the dilemma again by a sham; the lantern is carried on a solid cone rising from the base of the masonry dome, inside the timber dome, to the apex of the latter, and on that the lantern rests, not on the outer dome which appears to carry it, but which could not possibly do so. It is a very clever piece of construction, as solid as a rock; but somehow when we look at that leaded dome pretending to carry the lantern, which is really another construction protruded from beneath it, and which it could by no possibility carry, we feel our respect for what is in many senses a great building rather sensibly diminished.

The dome is a feature better fitted to be the architectural expression of a plan with a wide central area rather than the culminating point of a long plan, and every one who compares the present plan of St. Paul's with the plan of Wren's first design—on a Greek cross plan, with a small *pronaos* instead of a long nave—will feel, I think, that the latter is much more essentially a plan for domical treatment than the one executed. The dome lends itself very well, however, to the treatment of a plan consisting of several square areas adjoining on the plan of a cross or some similar arrangement (but not on one straight line), as at Venice (Figs. 86, 86A) and Perigueux (Fig. 88). In this manner the dome has been largely and effectively used, and the combination of a central dome with smaller ones grouped round it usually produces a fine effect.

On a great scale the dome appears to me to be, in spite of the difficulty of reconciling its internal and external treatment, the grandest architectural feature invented by man, and to have capabilities of higher treatment and finer effect than have ever yet been realized with it, externally at least. The Renaissance architects have had too much their own way with it, and have ignored its possible poetry of effect, and treated it in a too conventional and scholastic manner; but if an architect of genius had a chance, he might do more with the dome now than was achieved either in St. Peter's or St. Paul's.

Returning now to our wagon vault, let us see how the continuous vault, bearing on the walls for its whole length, became transformed into a vault exercising thrust only on certain portions of the wall, and how those portions were treated. The original form of the three-aisled mediæval church is found in the early Christian columnar basilica, as sketched in Fig. 89, plan 89A. This is, like the Greek temple, a purely trabeated construction, with its row of columns carrying the superstructure; only the columns have now ranged themselves inside the building, instead of outside.

As the arch came into play in buildings of this class, the flat lintel roof became a wagon vault, but with the points over the piers marked by transverse arches of greater thickness, as shown in the sketch of a bit from the Romanesque church at Valence, Fig. 90. Here also we see that a first step is made toward what was to become one of the great characteristics of Gothic architecture, the dividing out of the supporting piers into separate members each carrying its own portion of the design of the superstructure, architecturally speaking. Constructively, the pier remains as one mass, but it is broken up, for the sake of architectural expression, into separate members. As we see in Fig. 90, in place of the single column of the classic form, which does duty, on its own lines, in Fig. 89, the pier appears now in the guise of two much longer proportioned columns, one of which carries the arch of the nave arcade, the other carries the transverse arch or rib which strengthens the roof at these points. But the roof, constructively, is still a continuous wagon vault, not differing essentially from the simple form of the wagon vault as shown in Fig. 91. The great step was taken when it was discovered that two such vaults

GOETHE.—[See page 10326.]

* "Corbeling out" consists in building out, in the upper portion, beyond the line of the lower wall, by building each course of stones a little projecting beyond the one next below it.

† This is partly, however, the fault of an architectural quack named Carlo Madermo, who had interest enough with some pope or other to get the job given him of lengthening out the nave of the church, so as to destroy the composition of dome and substructure as Michael Angelo left it.

could be built interpenetrating, as shown in Fig. 92. The Romans used this form of vaulting, but did not hit upon the right architectural expression for it.

The state of things which this brings us to is that all the thrust of the roof is taken off the walls except at the four points whence the cross arches and the oblique arches spring, A, B, C, D. If we can make those points secure, we can play with the interspaces as we choose.

And how are we to support those points? Not by a feature like the column, for that is only a feature for resisting vertical pressure, and here we have a collection of pressures from different directions, but all (as they are from arches) thrusting outward. What we want is an opposing thrust inward to meet them, and that is supplied by the *buttress*, the well known form which is to Gothic architecture what the column is to Greek architecture; a form which, instead of standing vertically under the point of pressure, slopes outward from it, and thus strengthens the construction in the direction in which strength is wanted, and at the same time gives the correct and logical architectural expression. But it was only by very slow steps that this transformation of the column into the buttress was completed.

(To be continued.)

ELECTRICAL STRESS.*

By Prof. A. W. RUCKER, M.A., F.R.S., and Mr. C. V. BOYS, A.R.S.M.

IT is now some years since Dr. Kerr brought to the notice of the scientific world a most interesting method of demonstrating optically the stresses which exist in a dielectric between conductors of different potentials. His experiments have since been repeated and extended by Mr. Gordon, Quincke, Rontgen, and others. Mr. Gordon exhibited the phenomenon, using glass as the dielectric, in a lecture at the Royal Institution, and Prof. Silvanus Thompson tells us that he has shown it to his class with bisulphide of carbon. It is possible that others may have done the same; but in spite of these facts there is, I think, no doubt that the experiments are not as well known as their interest and importance demand.

Some weeks ago I had occasion to show one of them at a popular lecture, and since then Mr. Boys and I have been attempting to devise apparatus by which they might be readily exhibited to an audience. In the course of that time we have conversed on the subject with several well known electricians, and found that many of them had not seen the simplest of the phenomena which I hope presently to exhibit to you. I shall therefore offer no apology for bringing before the society a subject the theoretical explanation of which is for the most part well understood.

There is, however, another point of view, namely, that of the teacher, from which I think lecture experiments on the optical demonstration of electrical stress are valuable. It is very desirable that students should from the first be impressed with the fact that the dielectric plays a part in electrical phenomena as important as that of conductors. In no way, perhaps, can this lesson be more clearly taught than by the glow, which, when the dielectric is investigated by polarized light, indicates the stresses to which it is subjected.

I will, however, begin my lecture by exhibiting an experiment of another kind, which illustrates the same fact. It is practically a reproduction of the method by which measurements of the specific inductive capacities of various substances were at first attempted.

Three insulated metal plates, A, B, C, are arranged parallel to each other. The two outer ones, B and C,

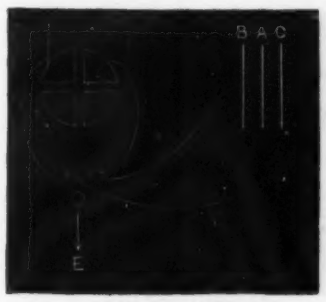


FIG. 1.

are in connection with the opposite pairs of quadrants of a quadrant electrometer. They can be put to earth by connecting the insulated mercury cups in which the ends of the connecting wires dip with a third cup which is not insulated. The middle plate is then charged without any effect being produced on the electrometer. On breaking the earth connections and pushing a plate of paraffin attached to a long ebonite arm along a groove which directs it between the middle and one of the outer plates, a deflection of the electrometer needle is obtained so large as to fling the index spot of light completely off the scale. The movement is in the same direction as that which would have been produced by reducing the distance between the two plates, and thus the experiment proves that induction takes place through paraffin more readily than through air. To meet the objection that the effect is due to the surface of the paraffin being moist or dusty, and that from these or from some other causes it has become a conductor, I touch it, and you observe that the deflection is unaltered. If, however, I repeat the experiment, inclosing the paraffin in a metal case, although the first effect is similar to that previously obtained, yet when I touch the metal the direction of the deflection is, as we should expect, suddenly reversed. [Experiment performed.]

Having thus illustrated the fact that the dielectric plays a part in the phenomena of induction, I may remind you of Maxwell's celebrated theory that it is, in such cases, in a state of stress. A tension exists along the lines of force, while a pressure is exerted in all directions at right angles to them. If this is so, we should expect that a structure equivalent to that of a crystal in its effects on polarized light would be produced. The properties of the substance would be different in directions parallel and perpendicular to the lines of force. The tension and the pressure would affect them oppositely.

This fact Dr. Kerr utilized. Assume that the lines of force are horizontal, and that plane-polarized light, the vibrations of which take place in a direction inclined at 45° to the horizontal, enters the stressed dielectric. Let matters be further simplified by supposing that the ray of incident light is perpendicular to the lines of force. Under these circumstances the single ray may be regarded as broken up into two in which the vibrations will take place along and perpendicular to the lines of force respectively. These rays will travel with different speeds.

On emerging from the dielectric they may be regarded as recombining; but since one has traveled faster than the other, they do not in general recombine to produce plane-polarized light. If, then, before the electrical stress was produced, a Nicol's prism had been arranged to cut off the plane polarized light, the production of the stress would modify the light so as to make it possible for a portion of it to pass through the prism.

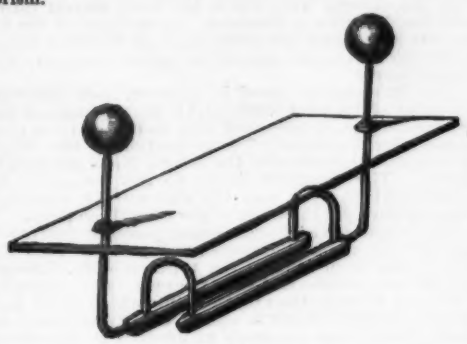


FIG. 1*a*.

A similar effect may readily be produced without the aid of electricity. I throw upon the screen the image of a small bar of glass. The light which falls upon it is plane-polarized, and now a Nicol's prism is turned so as to cut it off. The field becomes dark. If, however, the glass be bent, the concave side is compressed, the convex half is extended. The compression and extension take place in directions parallel to the length of the bar. Its dimensions perpendicular to its length are practically unaltered. Thus, its properties in directions parallel and perpendicular to its length are different. The incident light is broken up into two rays, which travel with different velocities. These on recombining do not produce plane-polarized light. Some of the modified light can traverse the second Nicol's prism, and as the bar is bent you see it brightly illuminated on the screen. Regions of compression and extension are separated by a black line. In the parts which it traverses no alteration is produced by bending; the light emerges—as it entered—plane-polarized, and fails to penetrate the second prism.

I will now show you Dr. Kerr's fundamental experiment, which proves that there is a close similarity between the behavior of the glass and that of a dielectric subjected to electrical stress. Dr. Kerr's observations were made by passing a beam of plane-polarized light between two metallic spheres immersed in carbon bisulphide. The light was extinguished by a Nicol's prism, but was restored when the spheres were oppositely electrified. It might, and probably would, be possible with great care and by using a liquid quite free from dust, to show the effect to an audience. It is, however, much better to use the apparatus shown in Fig. 1*a*. For spheres we employ two cylinders about 100 mm. in length. These are placed in a cell with glass ends, so that their axes are parallel and are perpendicular to the screen. Plane-polarized light is passed between them, and when an image is formed only the ends of the cylinders are seen, so that they present exactly the same appearance as two spheres would do. The light is extinguished by turning a Nicol's prism, but when an electrical machine, with which the cylinders are connected, is worked it is brightly restored (Fig. 1*b*). [Experiment.] For purposes of exhibition we obtain a great advantage by causing the light to traverse three or four inches of stressed liquid instead of a short distance in the neighborhood of two spheres. To prevent the cylinders from being drawn together by the attraction which

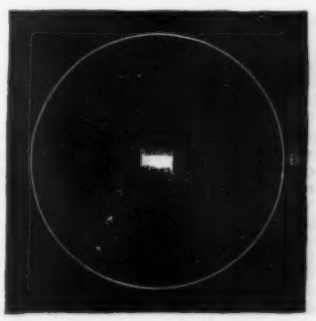


FIG. 1*b*.

exists between them when they are oppositely electrified, they are held apart by thin curved rods of glass, terminating in brass tubes which are soldered to the cylinders.

These experiments are attended with a certain risk, against which it is well to take precautions. The bisulphide is easily inflammable, and may catch fire if a spark passes in the neighborhood of the cell. It is therefore necessary that the cells should not leak. They are made of wood with glass ends, and the joints are made tight with shellac varnish. The wires which support the conductors are passed through plates of glass, which cover the cell and thus prevent the free escape of the vapor. To make assurance doubly sure, the cells are placed in a larger cell, so that if, as is sometimes the case, the glass ends are cracked by the passage of a spark through the liquid, the carbon bisulphide flows into the larger cell instead of falling on to the table or floor. This larger cell is itself placed in a wooden tray, the edges of which are turned up, and we have ready a tin plate extinguisher, which can be put over the whole apparatus in case the vapor should accidentally ignite.

The last experiment illustrates the fact that the dielectric between two oppositely electrified bodies is in a state of stress. An arrangement may easily be made to prove to a class that the tendency to separate observed in two similarly electrified bodies may be regarded as due to an attraction between each of them and surrounding bodies rather than to a direct mutual repulsion. Two cylinders arranged as before are placed between two vertical plates, which are parallel to the axes of the cylinders. Both cylinders and plates are immersed in bisulphide. The plates are connected with one terminal of the machine, the cylinders with the other. On electrification, two bright patches appear on the screen between each cylinder and the nearest plate. Taken in conjunction with the last experiment this illustrates the fact that there is an attraction between the cylinders and plates, and that the medium between the cylinders is not subjected to any considerable stress.

The next experiment introduces us to a point of some considerable theoretical interest. Glass touched by a hot poker becomes doubly refracting, because the temperature varies from point to point round the spot at which the heat is applied, but if it were uniformly warmed it would be singly refracting. There is, then, a difference between a crystal and a piece of unequally heated glass. In the former the molecules around any given point are differently arranged in different directions, but the constitution of the crystal is the same throughout. In the latter the temperature, and with it the arrangement of the molecules, varies from point to point. Now Prof. Quincke has shown that the volume of a dielectric alters when it is subjected to electrical stress, and the question arises whether the double refraction is produced, as it were, indirectly by this change of volume, or directly by what may be regarded as a crystalline arrangement of the molecules.

If the former view be correct, then as glass is doubly refracting only when it is unequally heated, a dielectric will exhibit the same property only when it is subjected to an electrical stress which varies from point to point. In the latter case double refraction will be produced by a uniform as well as by a variable stress.

Two parallel metal plates are now placed in the bisulphide; the light which passes between them is extinguished by the analyzing Nicol. The plates are connected with the opposite terminals of the machine, and as soon as they are electrified the space between them is illuminated. [Experiment.] (Fig. 2*b*.) If the

FIG. 2*b*.

bar of glass is held in front of the cell and bent, the black central line is broken. Where it crosses the stressed dielectric it is shifted toward the side on which the glass is compressed. Thus, when glass is compressed in a direction parallel to that in which the lines of force traverse the bisulphide, the double refraction produced on the liquid tends to neutralize that to which the compression gives rise in the glass (Fig. 2*c*).

Returning, however, to the question we were discussing, as to whether double refraction is produced in the bisulphide only where the stress is not uniform, it

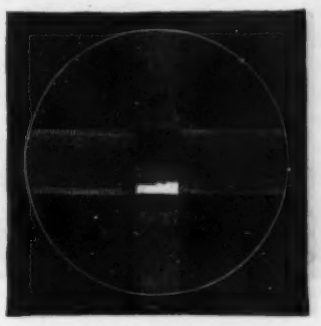


FIG. 2*c*.

is remarkable that if plane-polarized light is passed through a plate of glass, the opposite sides of which are coated with oppositely electrified conductors, and which is placed between crossed Nicols, no reillumination is produced by the electrification. This makes it important that the phenomenon should be more fully studied, and I will next show you an experiment which is conclusive as to the nature of the action in the liquid. The metal plates are replaced by two others

* Paper read at the Society of Telegraph Engineers and Electricians, on Tuesday, March 22.—*The Electrician.*

similar to them in all respects, with the exception that in the upper parts of each of the plates two windows are cut which are exactly opposite to each other. The light, therefore, which traverses the space between the upper parts of the plates passes six edges, that which travels between the lower parts is brought near two edges only, but penetrates a far greater thickness of uniformly stressed liquid. If the double refraction is due to a quasi-crystalline constitution induced in regions of uniform stress, the light, when restored by electrification, will be bright in that part of the image which corresponds to the lower parts of the plates. If non-uniformity of stress is essential, it will be brightest where it has passed near the greatest number of edges. [Experiment.] There is no doubt as to the result. The uniformly stressed region is much the brighter. In glass, on the other hand, it appears that a stress which varies from one point to another is necessary to produce double refraction.

The next experiment is devised chiefly for use in an elementary lecture. The metal plates are bent twice at right angles, so that on the screen they represent the inner and outer coatings of a Leyden jar. To make the illusion a little more complete, a knob is attached to one of the wires (Fig. 3*a*). When the conductors are

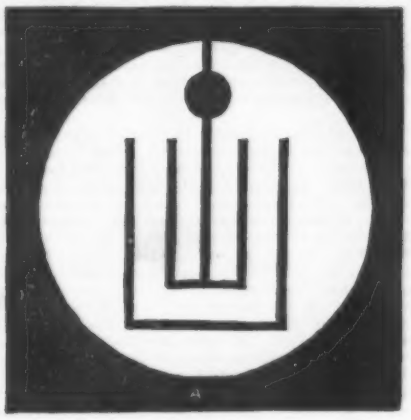


FIG. 3*a*.

oppositely electrified, a glow appears between them, which proves to the student that a stress is produced in the dielectric (Fig. 3*b*). At the two corners black brushes are seen, which are parallel to the principal planes of the two Nicols. [Experiment.] If before the

FIG. 3*b*.

plates are electrified the bar of glass be introduced and bent so that the black line which appears in its center coincides with the bottom of the inner conductor, it will be observed that on electrification the line breaks into three parts. Between the vertical sides of the

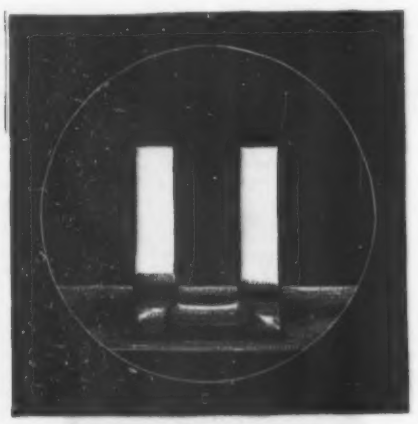


FIG. 3*c*.

Leyden jar the lines of force are horizontal, and the bar is so bent that, as in a previous experiment, the black band is shifted upward where it crosses them. Between the bottoms of the inner and outer coatings the lines of force are vertical, and the action will be reversed. The direction of relative compression and that of the vibrations which travel fastest in the stressed liquid, are both turned through a right angle, and here the black band travels downward toward the outer coating. [Experiment.] (Fig. 3*c*.)

I will next use as conductors two cylinders placed one inside the other, with their axes coincident. On the screen they look like two concentric circles. When the light is extinguished and restored by electrification, the black cross so familiar in experiments on crystals is immediately visible. [Experiment.] (Fig. 4*b*.)

FIG. 4*b*.

So far I have dealt only with cases in which the light which reappears on the screen is white; we will now modify the arrangements so as to produce color effects.

When a very thin crystalline plate is interposed between crossed Nicols, the light which traverses the second Nicol is white. You will remember that the restoration of the illumination depends upon the fact that the velocity with which the light travels varies with the direction of vibration. In the case of the dielectric, vibrations are propagated at different rates, according as they are parallel or perpendicular to the lines of force.

This difference of speed is, however, itself different for lights of different colors, and if the thickness of the crystalline plate is increased, very beautiful color phenomena are developed. The proportions of the different colors which traverse the second Nicol are widely varied. The emergent waves do not recombine to produce white light, and the tint actually observed changes with the thickness of the crystalline plate.

The images of two wedge-shaped pieces of quartz are now thrown upon the screen, and you see that the color varies from white at the thinnest ends, through orange, red, purple, and blue to green. [Experiment.] Curiously enough, the range of tints which these particular crystals exhibit is almost exactly the same as that which I hope presently to produce by electrification, though in the case of quartz the phenomenon is due to causes different from these I am now discussing.

In the case of a dielectric, colors will be exhibited if we increase the stress sufficiently, even if the length of the liquid column traversed by the light is not largely augmented. I will therefore use a "Franklin's pane" in which the two plates are nearer together than in the previous experiment. The risk of discharge from the one plate to the other is now greater. The plates are therefore made thicker and the edges are carefully rounded. [Experiment.] As the machine is worked white light first appears. Now it begins to turn orange, which changes into red and purple. [On repeating the experiment, the insulation was maintained until the green of the second order appeared on the screen.] The green of the second order is the tint which Dr. Kerr succeeded in reaching. Recently, when trying the experiment at South Kensington, we obtained the red of the second order, and have thus, I believe, carried the observations to a point on the scale of colors which had not been previously attained in this way. I will now repeat the experiment, placing a direct vision prism in front of the stressed liquid. When the plates are charged, a spectrum appears on the screen. [Experiment.] A black interference band now enters from the violet. As the difference of potential increases it blots out the green and invades the red at the moment that a spark passes, and the phenomenon disappears.

INDUCTION.

AT a recent meeting of the Physical Society, Mr. W. E. Sumpner, B.Sc., read a paper on "The Variation of the Coefficients of Induction." The author pointed out that there are three ways of defining the coefficient of self-induction of a circuit, expressed by the following equations:

$$e = L_1 \frac{d\,C}{d\,t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$N = L_2\,C \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$T = \tfrac{1}{2}\,L_3 C^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where e = back electromotive force due to change of current, C = current, N = total induction through the circuit, and T the kinetic energy of the circuit. If the medium be air, L_1, L_2, and L_3 are identical, but in the case of iron this is no longer the case. When the curve of magnetization is given, their values corresponding with any value of C can be easily determined by the above equations. Maxwell's absolute method of measuring self-induction gives L_2, and by a modification due to Professor Ayrton, where the current is altered from C_1 to C_2 instead of from 0 to $C = \frac{C_1 + C_2}{2}$, the value of L obtained is approximately L_1, if $C_1 - C_2$ is small compared with C.

From the known character of the curves of magnetization of iron, it is easily seen that the value of L_2 increases with the current when the current is small, then becomes nearly constant, and afterward decreases. For an electro-magnet having a horseshoe core of best Swedish iron ½ in. in diameter and 14 in. long wound with 800 convolutions, the value of L_2 for currents between 0·047 and 0·107 ampere was found to satisfy the equation

$$L_2 = \frac{A}{5} + 0{\cdot}0435,$$

where A = current in amperes.

A method of comparing self-induction with capacity is described in which the arms of a Wheatstone's bridge opposite the one containing self-induction is shunted by a condenser of capacity K. The bridge is balanced for steady currents, and the deflection θ_1 of the galvanometer observed on breaking the battery circuit. θ_1 is :: $L_2 - K\,p\,s$, where p and s are the resistances of the two remaining arms of the bridge. The condenser is then disconnected and another swing θ_2 obtained on again breaking the battery circuit; $-\theta_2$ :: is L_2.

$$\therefore \frac{\theta_2}{\theta_1} = \frac{L_2}{L_2 - K\,p\,s}, \text{ or } L_2 = \frac{\theta_2}{\theta_2 - \theta_1} K\,p\,s.$$

Further experiments were made on the electro-magnet when its poles were joined by a piece of soft iron, the currents being reversed. The resulting values of L_2, $\mathfrak{B}$, $\mathfrak{b}$, and μ are given in absolute measure, and from them the author deduces

$$L_2 = 0{\cdot}05 + 3{\cdot}9\,A$$
$$\mu = 210 + 720\,\mathfrak{b}$$
$$\mathfrak{B} = 210\,\mathfrak{b} + 720\mathfrak{b}^2$$

for values of A between 0·06 and 0·9. The difficulties experienced in determining the induction coefficients for strong magnetizing forces produced by the testing current are described. They arise chiefly from the fact that in order to obtain strong currents the resistances must be small. This makes the "time constant" large, and in order to obtain the values of L in absolute measure, a ballistic galvanometer of very long period would be required. A method of calibrating a galvanometer of comparatively short period to give approximate results is described. Where the magnetizing force is produced by an independent coil, no such difficulties present themselves. Results obtained for the coefficient of self-induction of a Gramme armature (A type), for different currents round the field magnets, vary from 0·0218 for current 0 to 0·0117 for a current of 29 amperes.

The value of L for a given point on the curve of magnetization is not a definite quantity, but has always two or more distinct values, depending on whether the magnetization is increased or decreased by the test currents, and on the previous history of the iron. That this must be the case is easily seen from the curves obtained by Professor Ewing in his "Experimental Researches on Magnetism." The values of L corresponding to the three sides of a small Ewing's cycle are denoted by L_p (progressive coefficient), L_r (return coefficient), and L_c (cyclic coefficient). L_p is always the largest, whether the magnetization be increased or decreased by the testing current. Numerical values of L_p and L_c obtained from a Kapp & Snell transformer are given. L_c can be very accurately determined by Professors Ayrton and Perry's secohmeter, and some of the results given in the paper were thus obtained.

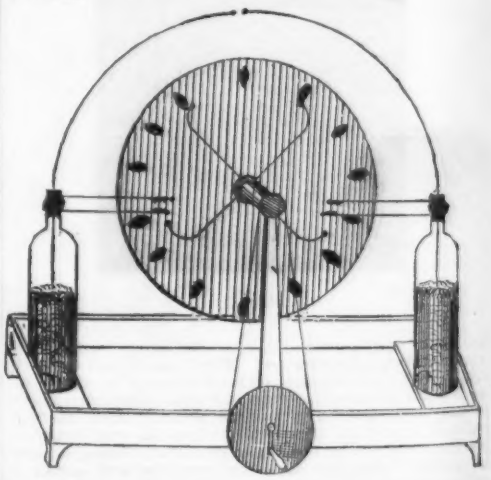
Having given the curve of magnetization and that connecting impressed electromotive force and time, a simple graphical method is described for drawing the current curve. Applying this to an alternating current, where the electromotive force is a pure sine function of the time, it is shown that the resulting current curve differs considerably from a sine curve. The case of the rise of current in the magnet coils of a dynamo excited by accumulators is also discussed, the derived curves being in accordance with observation.

In conclusion, the author pointed out that the time taken to discharge a condenser through a given resistance may be decreased by adding self-induction to the circuit, provided L is less than $\frac{1}{4}\,K\,R^2$. When $L = \frac{1}{4}\,K\,R^2$ the discharge is completed in one-half the time required when L = 0. This may account for the remarkable results observed by Dr. Lodge in his experiments on iron and copper as lightning conductors.

HOW TO MAKE THE WIMSHURST INFLUENCE MACHINE.

IT will require 8 ft. of matchboard, ⅛ in. thick, 7 in. wide, 1 ft. of hardwood, ¾ in. thick, 7 in. wide, 9 ft. of brass wire, ⅛ in. or ¼ in. diameter, four brass knobs, sheet brass, 9 in. by 7½ in., for sectors, nine large cotton reels, 5 lb. gun shot, small size, two ordinary white glass bottles, piece of tin, 2½ ft. of steel or iron wire, marine glue, etc.

The stand is made like a box without top or bottom, 3 in. deep, 26 in. long, 8 in. wide; at the ends are made two boxes, just wide enough to take the bottles (see drawing).



Insulating pillars are two common light glass bottles, with a good coat of shellac varnish inside and out; when dry put some pieces of silk inside, about an inch thick; also 2½ lb. of fine gun shot. On the outside about 3 in. of tinfoil, or tinned iron I prefer, as it is stronger, and seems better. Let a piece of wood take the place of corks, with a hole in the center; small cotton reels will do well, fixed in with marine glue. On these are fitted the hollow parts of two brass knobs, such as are used on doors; in the tops draw holes to receive discharging rods. At each side drill holes, to solder in pieces of brass rod, bent so as to form the letter U, just long enough to reach about 1 in. on disks; fix on these metal brushes, which will serve as collecting combs (see drawing).

Discharging rods are made from brass wire, with brass balls: large one is 2¼ in., smaller one is 1¼ in., filled with gun shot.

Disks are made of plate glass ¼ in. thick, 13½ in. diam.; either one hole about 1 in. is drilled in the center, or one just large enough to let the brass tube through, and two small ones to receive screws for screwing disks to bosses. These are drilled with an ordinary steel bit, holding the drill in a slanting position, keep-

ing the hole well supplied with paraffin and salad oil. This done, give them a good coat of shellac varnish.

Sectors are cut from sheet brass; they are 2¼ in. long, ¾ in. wide at one end, ½ in. at the other, 14 in number; warm them and give them a coat of marine glue, put them on an equal distance apart on disks, and ¼ in. from the edges; press down with a warm iron, which will fasten them to the glass.

Bosses and spindle: Take 10 in. of brass tubing, 9¾ in. of steel or iron wire, to fit inside tubing; at 1 in. from each end drill a small hole to receive screws; these are to secure spindle and tubes to stanchions. On each end solder binding screws, straight form, with removable nut, to hold neutralizing rods in their places. Remove the spindle, and cut the tube in the center, and at 1½ in. from each end, on the long pieces fit the large cotton reels to form bosses and pulleys. Disks are first fixed with marine glue, then screwed on. Use good metal brushes on neutralizing rods. It will be seen that a machine as thus described need not cost more than 12s. or 14s., and if properly constructed will give a 7 in. spark.

A few words about working the machine: To get the longest spark I find it best to have the neutralizing brushes about 3 in. apart, and the plates about ⅜ in. apart, the discharging balls much larger than usual, and the machine driven slowly for a few seconds, then rapidly, till discharged, the report being very loud from my machine. I have had no trouble to get a 7 in. spark during the frosty weather, and sometimes 8 in.

So many readers of the *English Mechanic* have written to me for detailed information that, with the editor's kind permission, perhaps this simple account in your valuable paper may be interesting to others also.—*F. S. Fowler, in English Mechanic.*

EXPERIMENTAL OPTICS.

IN the course of the last three of his recent series of six lectures at the Royal Institution on "Experimental Optics," Lord Rayleigh said that it is now known that the human eye cannot possibly be achromatic, and so much is this the case that it is surprising we do not notice it more in daily life, for under similar circumstances the defect would certainly be observed in an instrument made by an optician. If we look at a vertical bar of a window with one eye, then bring up the finger on one side so as to cover half the pupil of the eye, the bar will appear yellow on one side and blue on the other, which would not be the case if the eye were achromatic. Light, after being analyzed by a prism, is homogeneous, that is to say, it cannot be decomposed again by means of another prism, as Newton proved; yet Brewster argued that homogeneous light can be altered by absorbing media; the fact is that with absorbing media the light may be the same, but more or less bright, and the brighter lights appear yellower to the eye, but this effect is subjective, and is not always seen in the same degree by different observers. Apparent colors due to contrast can also be produced; flaws in glass and dust in the air will scatter light. Consequently in prism experiments, unless exceptional care be taken, a sensible amount of white or other light will be found distributed over the whole spectrum. Helmholtz has made known that all we have to do in testing the purity of colored light is to see if a prism will decompose it again; he therefore received the spectrum upon a screen containing perforations, and then examined with a prism the red or other rays allowed to pass through the openings in the screen. The second prism purified the light, and Helmholtz came to the conclusion that with a really homogeneous light absorbing media produce no difference in the color.

The speaker here performed a remarkable experiment by passing white light through a solution of bichromate of potash, which cuts off all the blue rays, then through a solution of litmus of a particular thickness, which cuts off all the yellow; yet the mixture of red and green lights then allowed to pass produced a bright yellow upon the screen. When the light upon the screen was analyzed, it was found to consist only of red and green. He then took a glass cell filled with a nearly saturated solution of common sulphate of copper, which cuts off the red of the spectrum. Next he introduced a cell of bichromate of potash to cut off the blue, so that nearly a pure green was left, with a little yellow in it, and this is one of the methods of obtaining nearly a pure green. Then he spoke of the rendering of fibrous substances, such as paper, transparent by filling up their interstices with liquids, and stated that a Swedish man of science had taken powdered glass, dried it, and then found a liquid of the same refractive index as the glass. A convenient liquid for the purpose consists of bisulphide of carbon and benzole, regulating the proportions to give the proper index. The first time he—Lord Rayleigh—made the mixture he did so in an ordinary test tube, and stirred it up with a glass rod. The rod could be seen projecting above the liquid, but only by the closest observation could its outline be seen in the interior of the mixture; so much was this the case that he handed the test tube round and asked his friends why the rod in it did not fall to the bottom of the liquid. Neither the glass nor the liquid, however, has an absolute refractive index of its own; consequently, when the two are adjusted for one part of the spectrum, they may not then be the same for other parts of the spectrum. He had had some glass bottles worked optically flat on the outside, and had eliminated the optical irregularities of the inside of the bottles as well as of the glass powder by the aid of the liquid mixture already described, but he had found the experiment more difficult than he had anticipated. Optical glass is best for the purpose; the next best is plate, and all dust and dirt must be carefully excluded. Detritus from the mortar must also be avoided. He used an iron mortar, and then separated the particles of metal with a magnet. The bottles transmitted green light and scattered the rest. By altering the proportions of the liquid or the temperature of the whole, the refractive index was also altered and a different color transmitted, but in such experiments the temperature must be uniform throughout the bottle.

In speaking of the transparency of a solution of chloride of chromium to the different rays of the spectrum, he gave the color curve of that substance as represented in Fig. 1. Chromium chloride is highly transparent to the red rays R, and largely transparent to the blue rays B; it is but slightly transparent to the yellow Y and the violet V. When the solution is in small thickness, the blue rays are transmitted freely; as the thickness is increased, they are cut off, and the red rays alone are transmitted. Hence this liquid in two different thicknesses appears to have two different colors.

In one of his experiments Lord Rayleigh feebly illuminated a white paper screen by gaslight, and in the center of the screen was a bright white circle of light thrown by the electric lamp. When the electric light was stopped, a nearly black circle appeared upon the screen in the place of the white one. The circle consisted of a neutral gray, nearly black, disk, which, under the influence of the electric light, had looked whiter than the screen upon which it was fastened. He then exhibited a variety of experiments with the color top.

Lord Rayleigh next called attention to Newton's diagram, Fig. 2, in which W represents white light, or a mixture of all the colors, and R red, Y yellow, G green, and V violet. According to this diagram, a mixture of R and G should produce a lighter yellow than Y, which Maxwell subsequently proved is not the case in fact. A more true color diagram is represented by Fig. 3, for every color between R red and G green can be obtained by mixing R and G, and every color between G green and B blue by mixing G and B. Thus green is a very important color in the spectrum. Let white light be represented by W, then the line W R represents the color curve of chloride of chromium, starting with white, for in very thin films all transparent solutions are white. Every color already known, and all colors that may hereafter be invented, can be made out of suitable mixtures of red, green, and blue. He then mixed blue and yellow lights, so as to obtain a kind of red color, instead of the green which might have been expected from experience in mixing blue and yellow pigments. By mixing green, yellow, and blue he obtained a neutral gray, like that obtained by mixing black and white—in fact, the colored mixture

FIG. 1

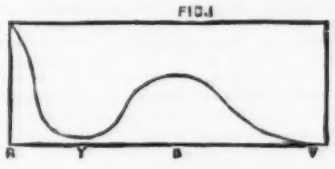


FIG. 2

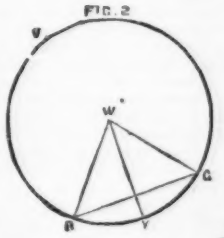


FIG. 3

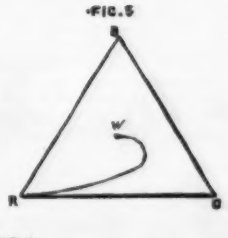
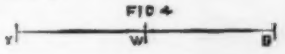


FIG. 4



had produced nearly a white color. Color vision, he said, is threefold, and the primary colors are red, green, and blue, if the primary colors have ever been seen by human eye. A man may make a threefold mixture of whisky, water, and lemon juice, but it does not follow that the ingredients with which he starts are pure. The way to see colors in the fullest splendor possible to us is to fatigue the eye in a certain way before looking at them. Thus, let the eye be fatigued for some time by gazing steadily at green and blue, then let it look at the spectrum; a brighter and purer red will be seen than otherwise would have been the case. When color matches are attempted to be made by mixing the colors of the spectrum—for those of the color top are hardly pure enough for the purpose—great differences are discovered in the vision of the experimenters, in the proportions say of red and green which they will mix, to make what appears to them a full yellow. Any difference from normal vision in this matter is usually of considerable amount.

As to color-blindness, he wished that its old name of Daltonism had been retained; the present term is objectionable. What are called color-blind persons have twofold instead of threefold vision. A person with onefold vision would be color-blind. In Fig. 4, let Y be yellow and B blue; then the white seen by a color-blind person would be between Y and B—say at W. In speaking of the diffusion of light, he said that the smoke of burning phosphorus is one of the best diffusers. It is exceedingly white and quite free from dirt, which latter is a powerful antagonist to diffusion. Opal glass is a good diffuser, but it stops at least 50 per cent. of light.

THE ORIGIN OF COLOR.

A PAPER on the origin of color, and the chemical constitution of coloring matters generally, was read by Professor Henry E. Armstrong, F.R.S., at a recent meeting of the Chemical Society in London. The origin of color in bodies was shown to be closely connected with the affinities of the elements composing such colored bodies, and therefore to depend on the valency of the elementary substances present, if the term valency be used in its broadest sense. Several chemists have endeavored to unfold the relationship which must necessarily exist between the chemical constitution of compounds and their colors.

Graebe, after his investigation on the constitution of quinone, communicated a paper, in conjunction with Liebermann, to the first number of the "Berichte" of the German Chemical Society on this subject, in which they pointed out that, excluding colored metallic salts, the color of organic bodies was destroyed by reducing agents, and that the quinones, all of which are more or less colored, give on reduction colorless hydroxy derivatives.

The constitution of quinone may be represented by the formula $C_6H_4\begin{matrix}O\\O\end{matrix}>$ and that of the hydroxy derivative by the symbol $C_6H_4\begin{matrix}OH\\OH\end{matrix}$ so that the union of the oxygen atoms with one another, represented symbolically by $\begin{matrix}O\\O\end{matrix}>$ appears to be the cause which produces the effect of color in this class of compounds. A withdrawal of two atoms of hydrogen from the hydrazo compounds similarly produced the azo coloring matters. Rosaniline, rosolic acid, and indigo also yield colorless derivatives on reduction. The arrangement of the oxygen and nitrogen atoms in organic coloring matters has therefore an important influence on the tinctorial properties of the body.

At the time when these earlier theories were advanced, the constitution and orientation of several of the more important coloring matters were imperfectly understood, and more recently the view advanced by Fittig that quinone may be considered a double ketone, or a body in which the oxygen atoms are not united to one another, but doubly united to different carbon atoms, has gained ground, and hence the intimate contact of the oxygen atoms in these colored bodies is not an essential condition for the production of color. Anthraquinone, the corresponding dioxy-derivative of the hydrocarbon anthracene, has, undoubtedly, the constitution of a di-ketone, and as it is a colored body, it affords additional evidence for a belief in the view just advanced.

In 1876, Otto N. Witt contributed to our knowledge of this subject an important paper on the "Bau und Bildung farbender Kohlenstoff verbindungen," in which he summarized the views he then held in the following laws: (1) The tinctorial properties of an aromatic organic compound is due to the presence of a color-giving and a salt-forming group in the compound. A color-giving group is called a "chromophore," and he cites the radical NO_2 as an example, while amidogen NH_2 and hydroxyl OH are examples of the salt-forming groups. A body containing a chromophore is called a "chromogen," thus in nitraniline $C_6H_4(NO_2)(NH_2)$ and nitrophenol $C_6H_4(NO_2)(OH)$, the chromophore is the NO_2 group, and the chromogen of these bodies is nitrobenzene ($C_6H_5(NO_2)$). (2) Bodies which contain a chromophore are more colored when they are in the form of salts than in the free state. (3) The more stable the salt, the more colored is the compound—when the same chromophoric base is employed.

Aniline, to take a further example, is a colorless base, and contains no chromophore; when nitrated by the introduction of the chromophore NO_2 the colored nitraniline is produced, and its salts vary in color with their stability. In coloring matters of this class, it has further been noticed that the two groups present—the NH_2 and NO_2 in the example taken—are in the same position as are the oxygen atoms in quinone, and known to chemists as a "para" or 1:4 compound. The two other nitranilines have not the same tinctorial properties as has the para compound.

Although chromogenic bodies are converted into dyestuffs by the introduction of such groups as NH_2 or OH, if these groups are altered by substitution of their hydrogen atoms, the color may be considerably modified. Thus a chromogen containing the group NHAc or OMe in the place of NH_2 or OH is colorless, as the basic nature of the compounds is reduced. If on the other hand the body contains the group NHMe in the place of NH_2, the color remains, and the compound is still basic. Phenolphthalein does not dye, while fluorescein gives a fugitive yellow color. If fluorescein, which is a weak acid, be nitrated or brominated, it is thereby converted into a strong acid, and can then form strong and valuable colors, of which the eosins may be taken as a type.

Similar reasoning may be applied to the nitrophenylamine and azo coloring matters. The origin of color may not, however, be due to the same or similar causes which make the body a dyestuff. The dominant idea which seems to underlie these speculations is that the union or valency of the elements present conditions the color of the compound produced. The paraffins with single affinities are inert and colorless, not only in the visible part of the spectra, but also in the ultra-violet and ultra-red portions, as shown by the spectroscopical investigations of Abney, Festing, and Hartley.

When two atoms of hydrogen are withdrawn from a paraffin and an olefine is obtained we have more active compounds produced and a beginning of color is manifested spectroscopically, and with a further withdrawal of hydrogen, as in the acetylenes, a still greater absorption of light takes place in the compounds produced. The color of compounds may therefore be due to a condition of strain within the molecules, as Baeyer some years ago endeavored to explain the properties of the acetylene compounds by the assumption that the affinity of the elements has direction, so that in compounds in which carbon atoms are "doubly" or "trebly" bonded together there was a displacement of the direction of some of the valency of the carbon atoms, which renders the compound liable to decomposition and capable of readily forming addition products.

A carbon atom may, according to Baeyer, have its valency distributed in space in the same way as are the angles of a regular tetrahedron inclosed in a sphere. Ostwald has advanced a similar view, and Armstrong has pointed out, in the *Philosophical Magazine*, that the saturated hydrocarbons have the valency of their carbon atoms unstrained and therefore free to act in certain directions, while in the unsaturated compounds a strained condition exists, rendering the bodies active and of comparatively easy separation.

Water, although viewed by the majority of chemists as a saturated compound, is able to unite as water of crystallization and in solution by virtue of what is termed residual affinity, and it is colored as shown by the researches of Russell, Abney, and others. Nitric peroxide NO_2 similarly is colored and unsaturated, while its polymer N_2O_4 is saturated and colorless. The unsaturated body is at a comparatively high potential and runs down, forming the saturated colorless body of low potential. Similarly, oxygen is colorless, while the unstable ozone is colored. The higher oxides, as a rule, have greater color than the low oxides of the same metal; as an example, the three oxides of lead may be cited. With the titanium oxides, the stable dioxide TiO_2 is white, while the unstable TiO

and TiO_2 are blue and yellow respectively. In the manganates and permanganates the high tinctorial power of these bodies seems to be due in some way to the large amount of oxygen that they contain. In the darkening of sulphur on heating, we have an example of the formation of simpler molecules of high potential.

Sulphur, again, unites with sulphuric anhydride to form a blue liquid, while selenium similarly combines with the same body to form a green compound, and tellurium a red one. Many of the colored iodides of the heavy metals unite with the alkaline iodides to form colorless salts with the evolution of heat, and the colored metals, gold and copper, similarly alloy with tin, forming colorless chemical compounds. Among the carbon compounds there is no example of a colored hydrocarbon, and most of the derivatives containing monad radicals are likewise colorless.

The strained condition which is, according to the view advanced by Professor Armstrong, necessary for the production of a colored compound is fulfilled in the organic dyestuffs, if they be considered all derived from a quinonic type, and the more important groups of coloring matters, viz., the azo compounds, rosaniline and rosolic acid, phthaleins, methylene blue derivatives, and indigo, may be so regarded.

MECHANICAL TOYS.

WE cannot allow New Year's day to pass without taking a rapid glance at the products of Parisian industry that it has just disclosed, at those toys that are sold for a few cents and are destined to bring joy into the world of children and, at the same time, momentary comfort among an interesting class of our laboring population. Here, for example (Fig. 1), we have a locomotive top revolving around a horizontal disk. This disk is stationary, and the top, which is connected with a movable disk lying upon the other, carries it along in its circular motion as a consequence of the friction of its pivot against the edge of the lower disk. The motion is the same as if the top was provided with a toothed pinion, and the stationary disk also was provided with teeth. This motion reminds us of that of the road locomotive, the difference being that the gear wheel of the latter revolves around a horizontal axle. In order to give the top sufficient weight, it is provided internally with a leaden ring. Furthermore, it is provided with apertures designed for the passage of air, which, when it is spinning, produces a noise like that

FIG. 1.—LOCOMOTIVE TOP.

of the whistling of a locomotive. The revolving disk supports a train of cars, which it carries along with it in the rapid rotary motion communicated by the top.

The little bird seen hopping about on its perch (Fig. 2) obtains its motion from rubber threads that are first tautened and then freed. This sort of motor is now much used in cheap mechanical toys. The perch is connected with a vertical axle capable of revolving in the base of the apparatus through the twisting of the rubber. The upper part of this axle is held by a wire ring. As the rubber upon unwinding would give the

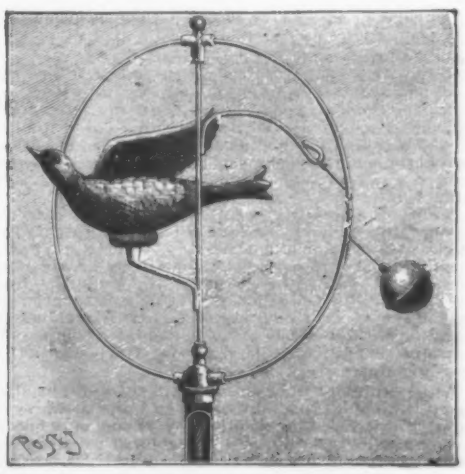


FIG. 2.—MECHANICAL BIRD.

axle, and consequently the bird, a continuous rotary motion, and not the jerking motion of hopping that it was proposed to obtain, a horizontal rod, a little shorter than the radius of the wire ring, is fixed to the vertical axle, opposite the bird, and quite a short thread attached to its extremity carries a small ball (a sleigh bell in the case under consideration). As the ball is thrown out by centrifugal force when the axle revolves, the rubber thread, on striking the ring, winds around one of the sides of the latter in consequence of the velocity acquired. When the ball is at rest, its weight makes it descend, the thread unwinds,

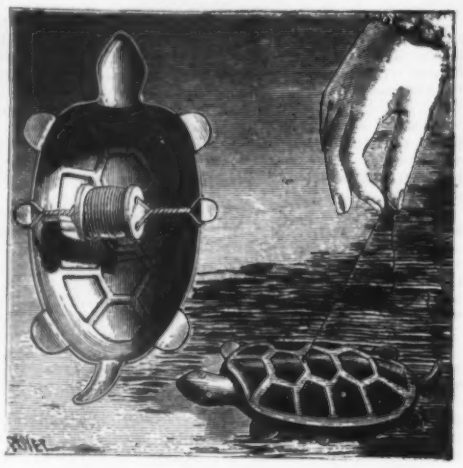


FIG. 3.—MECHANICAL TURTLE.

and the axle carries along with it the bird, rod, and ball, and makes another half revolution. The motion continues thus until the rubber has no longer sufficient tension.

The turtle (Fig. 3) has a still simpler movement. A string is held in the hand, to which the toy seems to be attached, and which, entering an aperture in the carapax, winds around a barrel that is supported by two rubber threads and runs over the floor. Upon pulling the string, it is unwound from under the barrel, the rubber is twisted, and its untwisting causes the turtle to walk, or, better, to roll forward as soon as the string is freed, thus permitting the latter to wind round the barrel.

One word only as to the toy shown at 1 and 2 in Fig. 4, and which it would be difficult to pass over in silence. It will be remembered that small telephones were formerly sold, which consisted of a tin tube having one end covered with a membrane through which a string passed. As these, for some reason or other, were not a success, the string has been reduced in length and the telephone converted into an apparatus

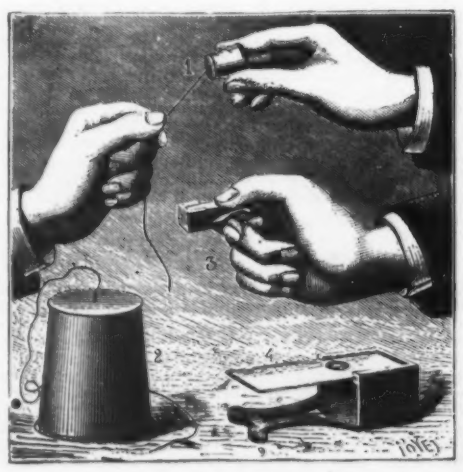


FIG. 4.—ACOUSTIC TOYS.

that produces the most diabolical and discordant sounds when the string is drawn through the hand, previously covered with resin.

The "cri-cri" (Fig. 4, Nos. 3 and 4), which made a fortune for its inventor, was another singular specimen of a noisy toy, of which the success is inexplicable. Since it now sleeps in oblivion, let us take care not to awaken it. Passing over the sewing machine, a marvel of cheapness, sold at six cents, and the wooden trumpet which imitates the voice of a crying baby, and is designed for travelers who wish to be by themselves in a car, let us say a word, in conclusion, of an

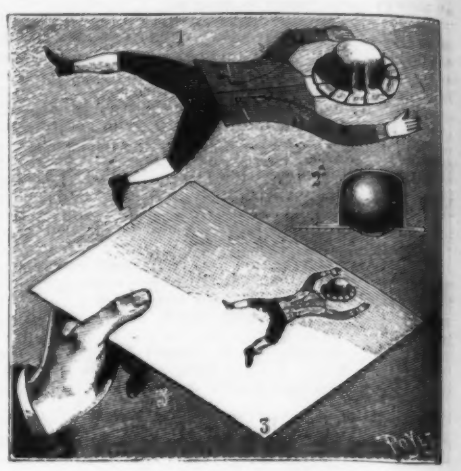


FIG. 5.—THE SLIDING MAN.

amusing application of the roller balls used in the industries for shifting heavy machines. Every small boy will tell you that in the course of the day he buys sixteen marbles for a cent. How, then, did the manufacturer proceed whose shop was recently besieged by the public, and who sold a single marble for three cents accompanied with a figure of a man cut out of paper, when fifty might have been had for five cents? Our engraving sufficiently explains the arrangement of the "Jail-breaker of Clermont" without the necessity of a detailed explanation. Remark only that the man's

FIG. 6.—THE NEEDLE COFFIN.

hat (Fig. 5, No. 2) is slightly less in height than the diameter of the marble, which turns freely within it and is held therein by a paper ring that allows it to roll over a plane surface, such as a sheet of cardboard, on which the figure rests. On giving the cardboard an imperceptible inclination, the marble moves in all directions, followed by the paper man, whose goings and comings much puzzle those who do not understand the ingenious trick.

"Make . . . (here follows the name of some prominent person) rise from his coffin." You take the

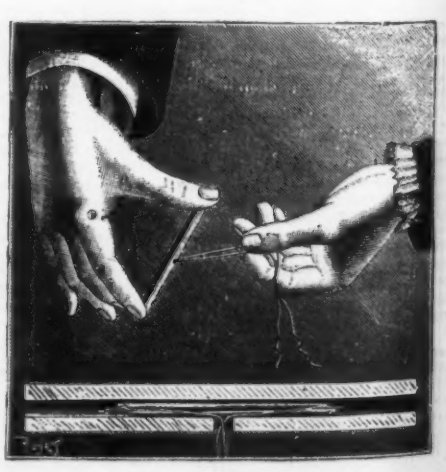


FIG. 7.—THE DECEPTIVE PENCIL.

little metallic coffin from the hands of the dealer, and, perceiving a button projecting from its extremity, you hasten to press it. At this moment you feel a needle prick your finger (Fig. 6). This needle is stationary and its point is flush with the end of the spring button, which is hollow. This joke, which is somewhat vulgar,

is nevertheless received everywhere with favor, it must be confessed, and the little coffins are sold by thousands. And yet this idea is not new. When a child at school, we inserted two needles in the stump of a pencil from which the lead had been removed (Fig. 7), and attached a string to the head of each and then passed the strings through a hole in the middle of the pencil. An innocent comrade was asked to hold the pencil between his thumb and forefinger, and to press very hard. Then, on our pulling the strings, the needles were made to protrude and the victim of the joke was forced to let go of the affair very promptly.—*La Nature.*

THE ORCHARD HOUSE.

FORTY years ago the orchard house, a primitive structure, was looked down upon by the profession as an amateur's toy, a sort of safety valve for letting off horticultural enthusiasm that might benefit the fruit tree nurseryman, but could never be of any use to the consumer of choice fruit. These gloomy predictions, so far as the hedge and the rough weather-boarded houses are concerned, no doubt are true, but there the jeremiads must cease, as we now find them superseded and supplemented by very large houses covering scores of acres in all parts of the kingdom. Many have been built as lean-tos against existing walls, more have taken the form of the true span roof running from north to south, not a few being set on piers—an arrangement which gives the tenant the option of moving them at pleasure—and all are erected upon the most approved principles, both as regards materials, workmanship, heating, and ventilation. So far the nurseryman and the builder have derived great benefit from the rapid development of this class of structure, and thousands of amateurs now spend many hours daily in the management of their own trees; but whether the orchard house has really brought down the price of stone fruit, as monster vineries have reduced the price of grapes, is a matter which does not trouble the consumer. In my opinion, the orchard house is beneficial to all classes of the community, and to none more so than the professional, who prophesied a short life for the bantling and a merry one for the nurseryman. Although plums, pears, figs, strawberries, cherries, and peaches are grown and grown well in the orchard house, the peach and nectarine stand at the head of the list. First, because there prevails an impression that they cannot be depended upon on open walls, and, second, because there is a good demand for all the surplus fruit that good cultivators can send into the market. To the private gardener the forcing orchard house is especially useful, as it saves the hard forcing of a permanently planted house. It gives him very early crops of ripe fruit, and enables him to test a great number of varieties on a small scale before he plants them out for training upon trellises.

HOUSES.

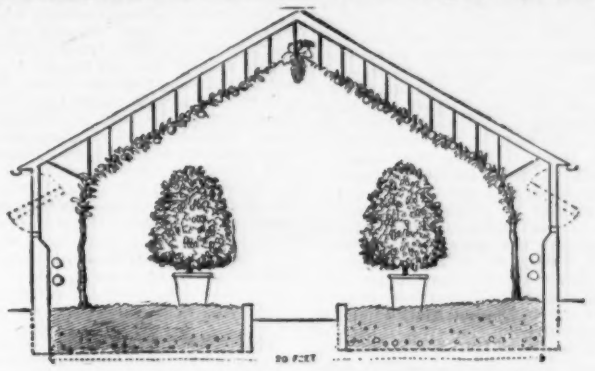
Air and light being two of the main factors in the production of good peaches, the span roof, a section of which is here illustrated, no doubt stands first on the list, and this is the structure I should always recommend to the gentleman who, having an open grass field, is about to make a new garden, or whose old one does not offer facilities for attaching to existing heating apparatus. In old gardens where good walls well furnished with established trees exist, the lean-to, a section of which we engrave, is not only the cheapest, but it is the best for early forcing, and for these reasons: The wall affords shelter from cutting winds and draughts, it saves a considerable item in the outlay, and facing full south or southwest, it absorbs a great deal of sun heat, which hastens the early maturity of fruit within a few months after the glass covering is finished. Variety being charming and the ability to test and compare the old and new sorts side by side a tower of strength, one, two, or more rows of trees in pots may be placed upon the border, where, under orthodox rules as to pinching and feeding, they will give a long succession and increase in fruitfulness as they increase in age. Where suitable walls do not exist I would not build specially for the sake of having a lean-to, but would erect a compact span roof, with sides and ends of glass, liberal ventilation, and an abundance of piping to insure the proper temperature, with plenty of air, without overheating. Early and late houses being of most use to the private gardener—the first for saving the first permanent peach house, the second for extending the season with all sorts of stone fruits and pears—the demand for a succession orchard house is of less consequence. Still, where it is considered requisite, the unequal span, with the longest side of the roof facing south or west and the shortest resting on a wall about six feet in height will be found suitable. The finest varieties of peaches, figs, pears, plums, and strawberries being grown in pots, the roof may be fixed, as the trees can easily be removed to the open air in the autumn; otherwise, planting out being preferred, the roof lights should be portable, for drawing off when full exposure of the trees to the elements is of paramount importance. A flow and return pipe along the back and front of a large house of this description will be ample, in fact, more than enough for fruit trees alone, which only require gentle fire heat when the fruit is setting, and again, for dispelling stagnant moisture when it is ripe; but with the view to filling it with flowering plants in the months of November and December, the addition of an extra four inch pipe is strongly recommended.

VENTILATION.

The fixed roof should have a roomy lantern ventilator running the whole length of the ridge, and the front lights, opening outward, should be capable of letting in more fresh air than the top ventilator can let out. By this means any forcing house can be kept full of fresh air, and what are termed keen draughts, so hurtful to tender foliage, can be avoided. Where the roof lights are portable all the upper section should run downward and the lower section upward, as fruit trees, especially plums, pears, and cherries, cannot have too much air during the time they are in flower and setting and again when the fruit is coloring and ripening. In fact, the cultivator should be able to reduce the temperature of any house to that of the external air throughout the hottest day in summer. Efficiently heated and well ventilated, the orchard house should be considered complete; but there is another item of equal importance which must not be overlooked, and that is

WATER,

for without this element, soft if possible, certainly abundant, successful culture will be impossible. I have often urged the formation of tanks for catching every drop of soft water that falls on the roofs of houses and buildings, and last year taught us a lesson which will not soon be forgotten. Soft water answers best for all purposes, especially for syringing, as it does not leave a deposit of sediment on the fruit and foliage; and supplementary to this, water from tanks, ponds, or running streams, after it has been well warmed and softened by exposure to the atmosphere, should always be at command for root-watering and damping the walls and floors. It is usual to construct large tanks beneath the floors of hothouses, but the hose in the orchard house being so frequently in request, while this mode of watering so greatly economizes labor, elevated tanks for this particular structure, if possible, should be provided in some part of the garden. Cold spring water is the worst of all, as it chills the tender foliage and washes out the stimulating matter contained in

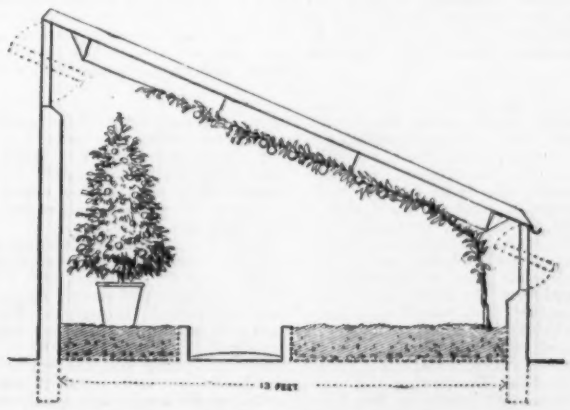


SECTION OF SPAN-ROOFED ORCHARD HOUSE.

the compost and top dressing; indeed, by the constant use of this water, plants of all kinds may be reduced to a state of starvation. Here, then, we have the choice of three qualities of water, good, indifferent, and inferior, and yet all these may be of great service in their way; the first for syringing, the second for watering, and the third for cleansing purposes. We often hear people say, give me a little and let it be good, but the orchardist should provide for an abundance of that which is good, and fall back on the inferior when the best fails, as too often it does in hot, dry seasons. Whatever kind of water is used, the supply must be plentiful and regular, for once a pot tree becomes dry, ten to one it is ruined for the season. From water pure and simple we turn to

STIMULANTS,

without which pot culture will make but very little progress. For general feeding there is nothing better than the drainage from the frame ground, the manure heap, or from well-fed animals. This, as a matter of course, must always be used in a clear diluted state, and most liberally when the trees are growing and the fruit is swelling. Slops from the house and soapsuds from the laundry also are good, but in gardens where none of these are within reach stimulants can be made by placing bags of animal manure, soot, and guano in large casks or tanks, specially provided for feeding purposes only. These highly concentrated stimulants together make a liquid which cannot be too carefully used, little and often, always in a clarified condition; but change of food being quite as acceptable to the fruit tree as to animals, each manure will produce the best result when mixed separately and supplied alternately. By adopting this plan, the soot water, in a clear, weak state, can be used once or twice a week for syringing purposes, and those who have never tried it will be astonished, not only on its effect upon the foliage, but also on its action as an insecticide.



SECTION OF LEAN-TO ORCHARD HOUSE.

COMPOST.

The staple for all pot trees is sound calcareous loam from an old pasture; if too light, it can be corrected with marl; if too heavy and clayey, old lime rubble and burnt earth will answer. The foundation formed and placed where it can be thoroughly pulverized and made free from wireworm by exposure to the weather, correctives such as crushed bones, soot, or Thomson's vine manure can then be added and thoroughly incorporated a few weeks before it is wanted for use. Rough charcoal, old hair plaster, and powdered bricks or oyster shells also may be used, both for mixing with the loam and for crocking purposes. But unless the loam is very poor, animal manure should be avoided. The most suitable compost for stone fruits should also be fit for roses and pot strawberries, but for pears and figs a somewhat softer but still a good fibry loam answers best. For one and all it should be mixed long enough for the loam to absorb the ammonia from the manures, and this process can be facilitated by throwing the compost in a heap in an open shed and covering it over with fermenting stable manure. The house, the compost, and the pots being ready, it will be well to see about the

SELECTION OF THE TREES.

Time being of more value than money, fruit trees established in pots and ready for bearing can be obtained from any good nursery, but unless great care has been devoted to the selection of compost, they do not always succeed so well as home-grown trees, while the cost of carriage to any great distance is heavy. Early autumn is the best time to choose and to pot, but maidens, which are the best to start with, may be potted as late as the end of February. If well grown on healthy stocks that suit them, peaches will average three feet in height; they will be as straight as arrows, well furnished with side shoots, clean and free from blemish at the working. The grower, if possible, should choose his own trees, but where he cannot conveniently do so, he may safely leave the selection to the nurseryman, as it does not pay to keep or send out an inferior article. Peaches and nectarines, two years from the bud and once cut back, can be obtained, but maidens beat them. All other varieties, figs excepted, can be secured from the open ground in the form of fruit-bearing pyramids or bushes.

POTTING.

Provided with clean, dry pots 9 inches to 11 inches in diameter, and compost in the best possible condition, potting should be proceeded with immediately upon the arrival of the trees. Having prepared them by shortening the strongest roots and trimming the fibers with a sharp knife, divide the trees into two sizes, the first for the largest, the others for the smallest sized pots. Enlarge the apertures to insure the free egress of water; crock carefully, finishing off with a little soot to keep back worms, and fill the pots one-third full with the roughest of the compost. If dry enough to bear ramming without becoming pasty, use the rammer freely, introduce the tree, fill in with compost, ram well as the work proceeds and finish off, leaving a space of 1½ inches below the rims for the reception of water and mulching. When all the trees are potted, place them in the house, attach neat labels, and give a moderate watering to settle the soil about the roots. If this work is performed before the leaves fall, it will be necessary to keep the house close, but not hot, and to damp the trees once or twice a day with a syringe, otherwise the trees, being bare of foliage and dormant, housing and watering will be necessary, while syringing may be dispensed with. Pears, plums, and cherries it is not absolutely necessary to place under glass, as they will winter very well on a dry, sheltered border where the pots can be protected from frost in the open garden. Peaches, too, may be left out, say from October to Christmas, but space being at command, the whole of them will not only be safe under glass, but being regularly supplied with water, the roots will at once set about recuperating and filling the compost with new fibers. Water, as a matter of course, should not be given immoderately, but just often enough to keep the compost in a nice growing condition, and although the house may be cool and airy, roots in quantity will be made by the time the buds commence swelling in the spring. As maiden trees cannot be expected to bear fruit until they have been a year in the pots, the house the first season will hold more trees than eventually it will accommodate, but duplicates be-

ing necessary and a rest advantageous, it is safe practice to start with a fair percentage above the number actually required, to fill up the chapter of accidents. In due course it may be necessary to enlarge the existing house or provide a second for the surplus trees, but this being impracticable, the peach, which is the king of orchard house fruits, must have full justice in the way of space; while plums and pears, after the fruit is set and safe from frost, may be plunged to the rims on warm borders in the open air.

STRAWBERRIES.

As all amateurs wish to grow strawberries in the orchard house, and the preparation of the plants takes up much time, the first step must be taken in June. At that time choose six-inch pots for late kinds and five-inch pots for early ones. Let them be clean, dry, and well crocked, and dust with soot to keep back worms. The compost recommended for peaches will grow the plants well, but if this is not ready, to three-fourths of strong calcareous loam add one-fourth of rotten cow manure and old lime rubble in equal parts and 12 per cent. of the whole of bone dust. Mix well in a dry, airy shed, as for peaches, a few weeks before the compost is wanted. Then fill the pots, ramming as the work proceeds until the balls are as hard as the top spit in an old pasture. Carry the pots to the strawberry beds, fix them in rows or blocks, and peg one good runner down upon the center of each ball. Water regularly and freely in dry weather, always after sundown, and do not allow a second wire to start from the young plant. In three weeks, more or less, according to the weather and the strength of the parents, the roots of the young plants will touch the sides of the pots, when they must be detached and conveyed to their growing quarters. Worms being great pests when they get into the moist, rich soil, the station should be made proof against them by a thick layer of coal ashes or lime rubble at the outset. Having ranged the plants nearly close together and quite level, keep them well supplied with water, soft if possible, never wetting the foliage when the sun is upon it, and rearrange them from time to time to keep the roots out of the bed and to prevent the foliage from becoming drawn. As growth in good seasons and in such rich compost will be rapid, stimulants should be dispensed with, one fine well ripened crown being always preferable to large ones, which split and ripen imperfectly. Toward the end of October it will be time to see about plunging the plants for the winter, not so much for the protection of the crowns as for the prevention of injury to the pots by frost. Where cold, shallow pits are not wanted, in these they may be plunged to the rims in leaves, old tan, or ashes, but not coddled, as the strawberry is perfectly hardy and fruits well in proportion to its winter rest. Lacking this convenience, with nine-inch planks on edge form stations in the open, plunge the pots where they will have full exposure to rain and snow, and never cover with aught save a few fern fronds when the frost is unusually severe. About the end of January the first batch of plants may be cleansed and taken into the orchard house, where they must never feel the want of water, as neglect in this particular will be fatal. But why not, many will say, take all in at once, or winter them in the orchard house? Simply because exposure to frost and snow and fresh air suits them best, while storing them away a great distance from the glass, exposing them to cutting draughts, and withholding water when the roots require it gives a great deal of unnecessary trouble and anxiety, if it is not a sure stepping stone to failure.—*W. C., in the Garden.*

[GARDEN AND FOREST.]

HOW THE MANGROVE FORMS ISLANDS.

AMONG the agencies that have helped to build up the peninsula of Florida may be numbered certain trees which are fitted by nature to grow on lands that are more or less under water and that are too unsubstantial to support other forms of vegetation. Like the coral builders, they work so slowly that in a single century no great change is accomplished, but in thousands of centuries the changes wrought are very great. The most important of these tree workers are the mangrove and the cypress. The former grows on shores and shoals that are overflowed generally by salt tide water; the latter in localities that are overflowed at times by fresh water. Both have similar obstacles to overcome, and they accomplish this by very different means.

The red mangrove (*Rhizophora mangle*) covers hundreds of square miles of the southern shores of Florida, the principal areas occupied by it being the shoals lying between the keys and the mainland—which are composed of calcareous sediment—and the low southern and western borders of the Everglades. In these localities and on tide-washed islands as far north as latitude 29°, it forms a dense thicket of vivid green, rising uniformly from high water level, unchanged by seasons, unaffected by hurricanes, insidiously encroaching on the domain of waters and helping build what in future ages will be dry land. Far in the interior, even on the northern border of the State, are found beds of calcareous sedimentary rock which may once have supported just such thickets of mangrove.

In places on the mainland shores the mangrove attains to tree-like dimensions, forming a tall trunk sometimes two feet in diameter. Like the cypress, the mangrove is provided with strong buttresses at the base, but these differ from those of the cypress in being of the style called by architects "flying" buttresses. Starting from the trunk a yard or two from its base, they descend in graceful curves, sending off branches, from which other branches proceed, all descending in similar curves to the muddy ground, over which the tides spread twice a day. These basal branches serve the double purpose of props and feeders. From the upper branches, aerial roots descend till they reach the water at high tide. Sometimes a tree may be seen entirely dead except as to one branch, which is kept green by sucking up water through an aerial root perhaps twenty feet long.

Another special provision for its environment is seen in the seed of the mangrove. This, before falling from the branch, develops into a miniature trunk from six to twelve inches long. The basal end being the heaviest, it is most likely to strike the muddy surface first and to stick there in an erect position. The rootlets and seed leaves being ready to push forth, the young plant makes a rapid growth and soon becomes well rooted and propped in its rather insecure position.

As the mangrove usually grows, rising scarcely ten feet from the water and spreading laterally, the main stem is of little importance. Innumerable roots descend from and support the leafy branches, repeatedly forking in their descent and forming a sort of basket work below high water level. Floating objects become lodged in these natural weirs, shell fish and other marine creatures multiply in them, and the submerged stems give support to sea weeds and hydroids. In some localities the roots become incased with oyster shells, and this, probably, is the origin of many of the oyster bars that obstruct some of the lagoons or so-called rivers of southern Florida.

The mangrove thickets in the course of time build up a foundation for other species. Of these none has a peculiar habit of growth except the black mangrove (*Avicennia nitida*). This tree is remarkable as to foliage, fruit, wood, bark, and roots. The surface roots send upward innumerable short feeders, black, lithe, and rising about a span above the surface. Their function evidently is to draw nutriment from the water at high tide, and, like the knees of the cypress, they add to the surface accumulations, which, from age to age, add to the elevation of the land. In this respect, however, neither of these trees equals the red mangrove.

The wood of the red mangrove sinks in water, and is not attacked by marine worms. Hence, fallen branches and trunks remain where they fall, while material that floats in with the tide is detained by the network of basal branches. It is altogether probable that the thousands of tree-covered "islands" in the Everglades and Big Cypress were once mangrove thickets, and that the present mangrove islands will in time be added to the mainland. As soon as they are elevated above the overflow of the tides, the mangroves will give place to species that require only brackish soil, which, in turn, will be replaced by fresh water or inland forms of vegetation.—*A. H. Curtiss.*

TREE PLANTING.

THE operation of planting trees requires deliberation and care. It should be done thoroughly or not done at all. Economy in tree planting means the proper preparation of the ground to be planted, and the use of well selected and well grown trees. The insufficient preparation of the soil and the use of badly-grown and badly-rooted plants is extravagant and wasteful, because such a course must invariably fail to produce satisfactory results. William Cobbet, who more than sixty years ago wrote what still remains the best book on planting which exists in the English language, exclaims, in speaking of the necessity of a thorough preparation of the soil, "How many millions have been *thrown away* in planting! How many thousands of plantations have at the end of twenty or fifty years made a beggarly exhibition; and how many of them have wholly failed! Yet, no truth is more evident to my mind than this: that no plantation ever failed, except from the manifest error of the proprietor. It is worse than useless to plant, unless you do the *whole thing well;* because, instead of creating a source of profit and of pleasure, you create a source of loss and mortification."

Trees may be planted in this latitude in spring or in autumn; in more northern parts of the country they can be safely planted only in spring. Whether they are planted in spring or in autumn, the ground should be prepared in advance. This should be done for spring planting the year before. This will give time to the soil to settle and become pulverized, and it will enable the planter to consider carefully what trees he will plant and just where he wants to set them. These are questions which should not be left unsettled until the short planting season arrives. The composition of an ornamental plantation—that is, the proper grouping together of different varieties of trees in a harmonious arrangement—requires much consideration and study. Satisfactory results will never be obtained if the arrangement of a plantation is left until the trees arrive on the ground. The proper preparation of the soil is the foundation of good planting. The best results will be attained by trenching by hand the area to be planted to a depth of two feet. The ground in this way is thoroughly broken up and loosened, and the roots of the trees can extend freely in all directions. Care must be taken in trenching to keep all the surface soil on top and not to mix it with the subsoil. Hand trenching is a slow and expensive operation, and few people will undertake it on a large scale in this country. When the ground is not trenched a hole must be dug for each tree. The larger and deeper they are made, the better the trees will grow. Holes twenty feet across and three feet deep are not too large, if large, long-lived, and healthy trees are expected. It is impossible to provide too much healthy nourishment for a tree. Small and shallow holes mean small, stunted, and short-lived trees.

All holes for spring planting should be dug during the previous autumn. As soon as dug the loam should be put back in the holes, and if the land is gravelly or rocky, the poor soil should be replaced by loam or peat carefully mixed through it. Peat furnishes valuable food to trees, and almost all varieties enjoy a liberal supply of it. The soil will be thoroughly settled in the holes by spring and all ready for planting, and the small, shallow hole actually necessary to receive the roots can be made then easily and quickly in the prepared soil.

It is always better to plant small trees than large ones. They are more easily and cheaply moved, recover sooner, and grow more rapidly. A transplanted tree two or three feet high will soon overtake and surpass a much larger one, and will grow into a more vigorous and beautiful specimen. A vast amount of money and a great deal of time is wasted every year in trying to transplant large trees.

It is not essential in digging up trees to preserve a large ball of earth about the roots. A very heavy mass of earth often breaks the tender roots, and is, therefore, a danger rather than an advantage to the tree. It is essential, however, to preserve as many of the small feeding roots as possible, and care must be taken in digging a tree not to unnecessarily break or mutilate them. All broken roots should be carefully cut away with a sharp knife before the tree is replanted. Care must be taken not to expose the roots to the drying influence of the sun and wind. They should be covered as soon as the tree is dug with a piece of cloth or matting, or they may be dipped in wet mud until they become thoroughly coated. The secret of successful transplanting is to have the soil brought into close and immediate contact with the roots. It is better, therefore, to plant in dry, and not in wet, rainy weather.

The coating of mud not only protects the roots from drying, but helps the earth thrown about them to adhere more closely. Two men are required to plant a tree. The hole should be twice the width of the mass of roots, and the bottom should be worked fine with a spade. One man should then hold the tree erect, with its roots carefully spread out in all directions in the hole, while the second man should break the soil taken from the hole, so as to make it as fine as possible, and then let it fall from the spade down upon the roots, while the first man should lift the tree gently up and down, that the fine earth may penetrate and fill all cavities about the roots. When the hole is nearly filled in this way, the earth should be pressed down with the foot, beginning at the outside of the hole and working in toward the stem of the tree.

The hole may then be filled and the soil rammed down solid. Tall trees should be carefully and securely staked as soon as planted. The operation is then finished. It is not uncommon to see water poured into the hole while it is being filled up. This practice does harm rather than good, as it washes the fine soil away from close contact with the roots.

Some planters recommend transplanting coniferous trees during the month of August, but this plan has little to recommend it; and it is certainly safer to move them in the spring. Many people believe, too, that they can only be safely moved late or after they have begun their annual growth. This is a mistake. Conifers can be safely transplanted just as soon as the soil is dry and friable. They can, however, be moved later than deciduous trees, as they begin to grow later.

These are the general rules for successful tree planting. Certain families or species sometimes require special treatment. Magnolias should be moved late, and after their roots are in active operation, which is shown by the unfolding of the leaf buds. Walnuts and hickories, as they have strong, deep tap roots, should, if they are to grow into fine trees, be planted when very small. Seedlings two or three years old, when finally transplanted, make the best trees. All the oaks make better trees when permanently planted young. This is true of all the white oaks. Some of the black oaks, however, especially the red oak and the water oak, can be safely transplanted, if they have been properly grown in nurseries, when they are ten or twelve feet high. Shallow rooting trees, like the maples, lindens, and elms, may be moved, with proper precautions, after they have reached a considerable size and age. Small specimens, even of these trees, move better, however, and in the end give better results and more satisfaction.

The man who plants one good tree thoroughly well, and then takes care of it after it is planted, does more for himself and the community in which he lives than the man who sets a hundred, badly selected and badly planted, or who neglects his trees after he has planted them.—*Garden and Forest.*

BOROFUCHSIN AS A STAIN FOR TUBERCLE BACILLI.

PROFESSOR LUBIMOFF describes in the *Meditsinskoe Obozrenie* a new stain for tubercle bacilli, which he calls borofuchsin. It consists of—fuchsin, 0·5 gramme; boracic acid, 0·5 gramme; absolute alcohol, 15 grammes; distilled water, 20 grammes. Prepared thus, it has a slightly acid reaction; it is quite clear and not liable to spoil by being kept, consequently it is always ready for use. The sputum is dried on a cover glass, and stained by being heated in contact with the borofuchsin for one or two minutes. The stain is then washed out by treatment with dilute sulphuric acid. The specimen is then washed with alcohol, and subsequently immersed for half a minute in a saturated alcoholic solution of methylene blue. After being washed in distilled water and dried, the examination of the specimen is made in oil of cedar or in a solution of Canada balsam. In exactly the same way sections of tuberculous organs may be stained after hardening in spirit, only in such cases the steps of the operation must be somewhat more prolonged. The main difference between this and other staining processes for Koch's bacilli is that, when borofuchsin is used, the process of washing it out with sulphuric acid is an almost instantaneous one. All other bacilli are, as when other stains are used, rendered colorless and invisible, the tubercle bacilli being alone seen.—*Lancet.*

DISTILLED HOT WATER AS A CURATIVE AGENT.

BELIEVING that my experiments may be of much use to many others, I will state briefly what has been learned by actual experience. I have been a great sufferer from dyspepsia and severe headaches for at least fifteen years. For the past few years the trouble has increased so that I was unfit for any kind of business. In one of my states of bodily prostration, it was given me to think that distilled water had the power and capacity for absorbing and cleansing the system from all poisons and obstructions whatsoever, and thus open the way to a healthy action of the vital organs.

Taking this water hot gives the body an internal bath and a sweat from within outward; opening all the sewers of the system and setting the blood coursing through every part of the body. Having concluded that this was a reasonable and safe experiment to try, I began in earnest to give it a fair trial, and to this end bent all remaining energy. The first thing was to secure the water (no easy task, I assure you), and for this purpose no less than nine different machines were made before a satisfactory apparatus was brought into existence.

Now I have an abundance of the pure crystal water, which is really enticing to look upon, in its purity and goodness. For ten weeks I have drunk it hot (nearly a pint) before meals and also before retiring at night.

The results are that the dyspepsia is getting away as fast as possible and the headaches are things of the

past. Although my head work is double what it was, it is now done with dispatch and pleasure as compared with the misery of a few weeks ago. I am much indebted to Dr. E. Cutter, of New York City, who gave me much encouragement and advice in pursuing this simple and, I believe, reliable treatment.

This is not a medicine to cure one complaint by bringing on another. It regenerates the whole system and makes the body a fit dwelling place to live in. Now, for the benefit of the sick poor, I have set up quite a plant in my shop, which makes about forty gallons per day, and it gives me much pleasure to say that this is entirely free to physicians for the sick poor who are prostrated with sickness. There is no doubt in my mind but that this simple, safe, and inexpensive treatment will cure dyspepsia, rheumatism, and gravel and possibly many other complaints.

There is one suggestion that seems proper to make in this connection, which is that there is a wide difference between the pure distilled water which I have used and condensed steam. One is pure and sweet, the other is unpalatable and impure.

It is also suggested that persons who take up this method should be reasonable, and not expect to be cured in one night, or even one month, of a trouble that has been fastened to them for years. Better conclude to follow it for six months; *that would be reasonable.—A. J. Chase.*

PROFESSOR AUGUST WILHELM HOFMANN.

AUGUST WILHELM HOFMANN, whose seventieth birthday was lately celebrated in Berlin, was born at Giessen. His father was an architect. He had the great advantage of studying chemistry directly under Liebig, and afterward of being engaged for some years as that chemist's assistant. In 1845 he took his doctor's degree with a treatise on the "Chemical Researches on the Organic Bases of Coal Tar." He then removed to Bonn as a private teacher, but a few months later, on the recommendation of Liebig, was appointed professor to the Royal College of Chemistry, in London.

This college, which was afterward absorbed into the School of Mines, was the school of many of our modern English chemists, who all remember Hofmann as a teacher with enthusiasm.

In 1862, at the request of the Prussian government,

PROF. AUGUST WILHELM HOFMANN.

Hofmann planned the famous laboratory at Bonn, and later on, a somewhat similar one at Berlin. He was asked to accept the directorship of either, and, having accepted that of Berlin, he left England and resumed his residence in Germany in 1865. During his residence in England he was elected a Fellow of the Royal Society in 1851, received the Copley medal in 1854, and was chosen president of the Chemical Society in 1861. He reported on the chemical sections of the exhibitions of 1851 and 1862, and was a member of the juries of both of these and of several other exhibitions abroad. He has written numberless treatises and papers on all branches of chemical science. He led the way in the aniline investigations which have given a vast new industry to the world, and more than any other he has contributed to an acquaintance with the formation of alkaloids. Cyanides, phosphides, bromides, sulphides, coniine, pyridine, piperidine, toluidine, and many other substances like these, keys to modern chemistry, have been worked upon with remarkable results by Dr. Hofmann. His popularity as a teacher in Berlin is attested by his class of 400 students, who listen fascinated to his two hours' lectures. Age seems to have no effect upon him. He is as active, as energetic, as exact in his experiments as he ever was, and as well up in the latest developments of chemistry as the youngest and most enthusiastic of its teachers or students. On the occasion of his birthday the Emperor Frederick conferred upon him a patent of nobility entitling him to the use of the coveted "von" in future, and the Empress Victoria and the Queen of England sent him their portraits handsomely framed. The governing body of the German Chemical Society presented to him in the course of the day a congratulatory address, signed by Sir Frederick Abel on behalf of the chemists of Great Britain, by Signor Cannizzaro for those of Italy, and by Mr. Wolcott Gibbs in the name of the *savants* of the United States, and accompanying the address were a marble bust of the professor and a sum of 30,000 marks, to be devoted to the foundation of a Hofmann Institute. Among the subscribers to the projected institute are many Englishmen, Italians, French, and Russians, besides Germans and Austrians. Professor Hofmann likewise received a large number of congratulatory telegrams, addresses, and diplomas from scientific societies and corporations at home and abroad.—*Chemist and Druggist.*

A NEW METHOD FOR THE SEPARATION OF TIN FROM ANTIMONY.

By H. N. WARREN.

THE slags, essentially a silicate of iron, containing, besides notable quantities of tungstic oxide, traces of lead, copper, and titanic oxides, are treated by the following method: After careful grinding of 2 grms. of the slag, the portion is at once introduced into a platinum dish, and treated with an equal mixture of pure hydrofluoric and hydrochloric acids. The whole portion of the slag, after digesting for a few minutes, is entirely decomposed, the greater portion of the SiO_2 being volatilized as SiF_4, the remainder passing into solution and containing besides the whole of the tin as $SnCl_4$, besides other impurities. The solution, after being filtered, is gently heated and saturated with SH_2, the whole of the tin, besides the impurities present, being precipitated as sulphides. The precipitate collected is boiled with NaHO, to separate the bismuth and cupric sulphides present. The solution now contains pure sodio-sulpho-stannate of antimony and tin, which is reprecipitated by the addition of HCl. The antimony and tin sulphides now obtained are decomposed by means of aqua regia, and contain a large excess of HCl, both of which pass into solution as antimonic and stannic chlorides. The solution evaporated to a small bulk, to deprive it of any large excess of HNO_3 that may be present, is diluted with a moderately weak solution of HCl. To the acid solution obtained an excess of potassium ferrocyanide is added, and the solution—which should now possess a clear blue color, provided sufficient K_4FeCy_6 has been added—is allowed to boil. The whole of the tin is thus precipitated as stannic ferrocyanide, being insoluble in an acid solution, and, as there is no such compound as antimonic ferrocyanide, the antimony consequently remains in solution (which may afterward be precipitated by SH_2 and estimated in the usual manner). The precipitate containing the tin is now dried and ignited, a few drops of HNO_3 being added, which speedily destroys the organic matter present. The residue is now introduced into a crucible provided with a tubulated lid, and reduced by means of hydrogen or coal gas, allowed to cool, and dissolved by means of HCl. The tin precipitated as sulphide, oxidized with HNO_3, and determined by the usual method.

The analysis and separation of tin from antimony in alloys may be conducted by precisely the same method, save that the alloy is dissolved by means of aqua regia in place of HCl+HF.

The precipitated antimony sulphide, after the separation of the tin by means of K_4FeCy_6, should possess a bright reddish orange color, entirely free from any brown coloration.—*Chemical News.*

ON A FREEZING MIXTURE.

By I. A. BACHMAN.

THE most commonly used mixture for obtaining, on a small scale, temperatures between −20° and −40° C. is that of snow and commercial hydrochloric acid. Since diluted sulphuric or nitric acid can be similarly used, it was thereby suggested that we might utilize for this purpose the mixture of equal volumes of strong nitric and sulphuric acid which had been employed in a Grove battery and for which we had little further use, frequently throwing away much of it. When first made, the mixture of acids has a specific gravity of about 1·63, and when spent about 1·57.

Mr. Bachman undertook to ascertain in what mixture this spent acid can be best employed for obtaining a freezing mixture. The temperature of the atmosphere in which the trials were made ranged from −2° to + 2° C., and in each instance the acid was brought to the temperature of the air before mixing with the snow. Diluting the acid with differing amounts of water and mixing these with snow, it was found that the undiluted acid and that diluted with one-tenth of the volume of water gave equal diminution of temperature. Any large addition of water lessened the cooling effect.

The following results were obtained:

100 c.c.	acid	and	225	grammes	snow	gave	fall of	31° C.
100 "	"	"	285	"	"	"	"	32° C.
100 "	"	"	340	"	"	"	"	30° C.
100 "	HCl	"	200	"	"	"	"	30° C.

As there was so little difference in the result when the snow was used within so wide limits, it was found most satisfactory to mix the snow with the acid until it attains the consistency of a thin mush, thus dispensing with all weighing. It is to be noted, as is explained by the above, that when the snow is wet, the temperature to be obtained with it is almost as low as when it is dry, which is far from being the case when hydrochloric acid is used.

It will also be seen from the above figures that when working at a temperature near zero, the "spent acids" answer as well if not better than hydrochloric acid; but when endeavoring to obtain lower temperatures than −30° C. by previously cooling the acid, it was found that better results were obtained with hydrochloric acid.

I will add that when snow is not available I have found satisfaction in employing shaved ice for this purpose.—*Amer. Chem. Jour.*

DETECTION OF ADULTERATED GROUND BONES.

GROUND bones are frequently made from bones that have been deprived of their gelatine by boiling. In this way the nitrogen is lowered, and the phosphoric acid unduly increased. To remedy this the manufacturer often adds scraps of hoofs and similar nitrogenous matters, and at the same time he puts in sand or gypsum to bring the amount of the phosphoric acid within normal limits. The author has applied a similar process to that employed for the detection of alum in flour, viz., by shaking the suspected sample up with chloroform. When this is done the genuine bone powder sinks to the bottom, while the spurious additions float. No genuine sample of ground bones will show more than 5 per cent. of floating particles.—*E. Heiden, Chem. Zeit.*

ON THE REMOVAL OF ARSINE FROM HYDROGEN SULPHIDE.

FOR the purification of hydrogen sulphide made from the ordinary reagents, O. Jacobsen recommends passing the gas over some solid iodine before it is washed with water. This method is based upon the well-known facts that arsine and iodine react violently at the ordinary temperature, forming arsenic triiodide and hydriodic acid, while hydrogen sulphide does not act at all upon iodine in the solid state or dissolved in strong hydriodic acid. Experiment showed that 2 to 3 grammes of iodine were sufficient completely to purify a current of hydrogen sulphide made from the ordinary reagents, and running uninterruptedly for a day. The iodine is coarsely powdered, dried in the air, and then placed in a comparatively narrow glass tube, 30–40 cm. in length, a layer of glass wool being put at each end. In chemico-legal examinations, it is recommended that a second shorter tube containing some iodine be introduced, and that after the analysis this be sealed and put aside. If it can be shown that the iodine in this second tube contains no arsenic, evidence will thus be furnished that the hydrogen sulphide used was pure. It is not advisable to dry the iodine thoroughly, as the reaction is aided by the formation of a thin layer of a solution of iodine on the particles of iodine. If it is desired to purify hydrogen, this should first be passed over iodine as above described, then over glass wool which is moistened with a concentrated solution of potassium iodide, and finally washed with caustic potash. —*Berichte der deutschen chemischen Gesellschaft*, 20, 1999; *American Chemical Journal.*

BOWLDERS IN COAL SEAMS.*

By Mr. W. S. GRESLEY, Assoc. M.I.C.E.

MR. VAUGHAN CORNISH having delivered an address illustrated by numerous diagrams on the "Artificial Reproduction of Minerals and Rocks," in which he showed the principal methods which had been employed in this kind of work, the meeting was devoted to the consideration of the question of the occurrence of bowlders in coal seams. A short communication was first read from Mr. Woodward, describing three bowlders found in the Trencherbone Mine at the Newtown Collieries, at depths of 950 to 1,000 feet below the surface, twenty or more being found in an area of 1,000 square yards. One of the bowlders had a groove in it, and another was of rather more quadrangular shape than is usual.

A paper by Mr. W. S. Gresley, Assoc. M.I.C.E., F.G.S., on "Bowlders in Coal Seams," was then read by Mr. Mark Stirrup (in the absence of the author). Mr. Gresley stated that the paper was intended to supplement certain references made in a recent paper read by Mr. Stirrup. Dealing first with bowlders taken out of the coal seams or from the overlying beds, they found that Phillips mentioned in 1885 the finding of a bowlder composed of quartzite or hard sandstone in a coal bed near Newcastle-on-Tyne. In the museum of that town there was a group of small bowlders (some being pebbles), among which was one from the "Main" seam—probably the lowest workable seam of the upper coal measures of Durham—at Cockfield Pit. Another one came from the top of the "Three-quarter" seam at Lands Pit. The composition of all these stones seemed very similar, viz., gray quartzite, and they were all well rounded. In the quarries of Messrs. R. Kell & Co., near the same town, a rounded foreign pebble was found last year. It occurred in the center of a large block of stone, at a depth of 15 feet from the surface of the bed. A large piece of transported rock of volcanic origin, 17 inches by 15 inches by 12 inches, had been found near Burntisland, in Fifeshire, embedded in the carboniferous strata, but it had the aspect of a bomb rather than of a bowlder. Again, at Oakesthorpe Colliery, Derbyshire, a layer of well-rounded bowlders and pebbles was seen in 1855. The bowlders lay on the top of the seam, in a lenticular patch of shale, which took the place of the regular sandstone roof. This instance was mentioned because the matrix of the pebbles was shale, which had probably replaced the sandstone, and it was an interesting and curious discovery. In North Wales a pebble had been found in the Rydegaled mine, and in 1862 a rounded piece of white quartz found in a bed of coal was exhibited, which came from a mine near Church. In 1865 large rounded quartz pebbles were reported in shales and ironstones lying near the base of the upper thick measures at Apedale. They were in the middle of the coal measures of that coal field, which were about 6,000 feet thick.

In April of last year, bowlders were found at Worthley in and overlying coal beds. They occurred at about 30 feet below the surface, and the largest, which was coarse gritstone, measured 2 feet 6 inches by 2 feet, had a smooth surface with slight striæ, and was found in the shale just over the coal seam. The others were much smaller in size, and were all embedded in the coal itself. In a Shropshire colliery a water-worn pebble, of lead ore, was taken from the top of a coal seam in the workings. Two years ago he (Mr. Gresley) obtained a smooth, flat quartzite pebble from the middle of the "Roaster" coal, at Heather. The pebble lay at 12 inches from the top, and appeared to contain worm burrows. In 1883 a group of much larger stones was discovered at the same mine completely embedded in the coal, while 500 yards away a bowlder of similar character was found in the same coal. A layer of water-worn quartz pebbles was found on the top of the coal at the Clifton coal mines, Queensland, 80 feet from the surface.

New Zealand had also furnished very similar pebbles. He might also refer to the occurrence, in South Wales, of pebbles composed of cannel coal, met with in the roof of a seam of ordinary coal. In the Kanawha Valley, West Virginia, it was stated in 1881 that in a sandstone roof in one place where a fall of roof occurred, exposing a section of sandstone, a number of blocks of coal, embedded in rock, were shown. They were not stringers or layers, but angular blocks of splint (hard, dull-lustred, coarse fibrous pure coal), as well defined as though they had been picked off a coal car and placed in the sand while it was being deposited. In the same year the manager of the Moira colliery, Leicestershire, noticed a large, angular, rugged block of coal, completely enveloped in the floor of the seam, measuring

* Abstract of paper read before the Manchester Geological Society, April 10, 1888.

about 2 feet 6 inches across and 2 feet thick. That this lump of coal was an erratic seemed evident.

Turning to the subject of traveled stones in under beds of coal seams, Mr. Gresley stated that a bowlder was found about twenty years ago lying immediately beneath the "Little" coal seam at Church Gresley, Derbyshire. It was composed of hard, crystalline sandstone, dotted with small angular quartz pebbles, and had a smooth surface. It was 10 inches in diameter and 6 inches thick; in the latter particular it corresponded exactly with the thickness of the under clay of the seam in which it lay. Three years ago a group of small, hard, light gray quartzite pebbles had been found in the same seam of the same mine, and last year another one was met with. The rock of which the last one was composed was a quartz conglomerate, with a few grains of some black mineral, and all the pebbles were well rounded. Now it was worthy of special note that the underbed in which they were found was not, strictly speaking, a fire clay; it rested, however, upon a seam of inferior fire clay, in which might be seen the usual so-called stigmaria roots and rootlets. With regard to the more or less pebble-like concretions occasionally found enveloped in coal beds (stones unquestionably formed *in situ*), two or three varieties were known. Upon the question as to how the bowlders and pebbles got into the coal or into the under clay he called attention to one or two points. So far as his own observations had gone, every stratum from which an erratic had been taken showed from its laminated structure that in all probability it was either deposited or accumulated in or under water, and, therefore, the bowlders must have been also transported by the agency of water. Now, if the traveled pebbles and bowlders were carried by being entangled in the roots of trees, brought down by floods and then let drop to the bottom, it was evident that carboniferous trees grew in other positions besides in the coal measures themselves.

Looking at the remarkable absence of connection between the so-called stigmaria in under clays and the overlying coal beds, and at the fact that coal itself was stratified in a remarkable manner, they had to admit that the presence of erratics in under clays affected the whole question of the mode of formation of coal seams. It seemed only natural and reasonable to suppose that one and all of these objects were brought in by one and the same agency, whatever that was. As to the idea that bowlders had fallen from melting icebergs while they floated over the spot, it was supposed that the climate of the period prevented their formation. But what proof had they that the vegetation of the coal epoch was unsuited to an Arctic climate? The existence of the traveled blocks and pebbles proved that long before the completion of the coal measures coal seams had become mineralized and consolidated in some places, and upheaval and denudation had taken place. Either the vegetable matter soon became coal or the time through which the coal period ranged was vastly greater than many imagined. It did not follow that because erratics were met with in coal mines that they must of necessity have been obtained from the coal measures. In conclusion, he trusted his remarks might help to elucidate the question of the geological history of the erratics of the coal period.

JOHANN WOLFGANG VON GOETHE.

IN all German literature there is perhaps no more commanding figure than that of Goethe. As poet, dramatist, critic, and scientist he stands almost alone. In the last named capacity his prescience and scientific imagination enabled him to utter at least one scientific prophecy that has had a remarkable verification.

He was born in Frankfort on the Main, August 28, 1749, and died at Weimar, forever illustrious from its association with him and his works, on March 22, 1832. His father, Johann Caspar Goethe, was of but low extraction, but had raised himself to the rank of imperial counselor. His father and mother were of widely opposite character, and Goethe, in his peculiar egoistic view, traced the different qualities he possessed to his two progenitors. In Frankfort he became imbued with the spirit of life in its historical and modern motives. He came in contact with both elevating and low associates, and from the combination acquired the fullest conception of humanity in all its aspects.

Leipsic was the first scene of his collegiate studies. Here he began his university career at the age of sixteen. He is believed to have studied less than he should have, were he to be judged only by common standards. When he reached the age of twenty-one, he went to Strasbourg and studied jurisprudence and the natural sciences. Here he made some of his famous friendships, notably that with Herder. The latter told him of English literature, and opened to him the Hebrew Scriptures. In 1771 he left the university, and a year later began to practice law in Wetzlar. He had now produced two dramas, and in 1773 wrote the *Gotz von Berlichingen*, which obtained wide celebrity.

During these years he had periodically fallen in love with various ladies, but at Wetzlar he reached the culmination by becoming enamored of a young lady who was betrothed to a gentleman whom she soon afterward married. A student named Jerusalem, an intimate friend of Goethe, committed suicide because of a fruitless love for a married lady. These occurrences seem to have inspired the author, and the unhappy passion of his friend is embalmed in the *Sorrows of Werther*.

His book, glowing and sentimental, had an immense success in the land of sentiment, the country where Jean Paul Richter was a possibility. It was published in 1774, when the author was but twenty-five years old, and his fame was made. It brought him to the attention of Augustus, the Grand Duke of Saxe-Weimar, and the city of Weimar was thenceforward his home.

He now wrote and studied, blending the more serious pursuits with much of pleasure and gayety. His general literary achievements are too well known to need recapitulation here. The theory of his life was that of living in the fullest sense of the word, of partaking of even pleasures that are properly considered forbidden. While the morality of this scheme cannot but be very seriously condemned, it is possible that the poet's excesses were an education in a certain sense, and that in his own troubles and disappointments and possible remorse he found the inspiration for Faust.

In science, he wrote on optics, attacking Newton's position with reference to colors. His "Beiträge zur Optik" and "Farbenlehre" are the titles of two of his works on this subject, the latter of which is especially directed against the English philosopher. He also wrote on botanical and anatomical subjects, and in his scientific work produced another illustration of his wonderfully versatile abilities.

At Jena, in 1794, he met Schiller. While the relative merits of the two were much discussed, Schiller dying the earlier left Goethe in undisputed possession of the field. Faust was produced in 1805, after he had known Schiller intimately. While at Jena he heard the cannons of the contending forces in Napoleon's battle of October 14, 1806. He declaimed in poetic terms against the misfortunes of his sovereign and his country, but was overcome in turn by Napoleon's overwhelming personality. He had an interview later with the conqueror. The latter told him that he had read the *Sorrows of Werther* seven times. Goethe was invited to Paris, and was invested with the cross of the Legion of Honor.

In 1825, the fiftieth year of his residence at Weimar was celebrated with great pomp. In 1831 he produced the second part of Faust. He died at eighty-three years of age. His last words were "More light."

His scientific prescience has been mentioned. He is said to have predicted that electricity would have successful applications, but to the minor affairs of life, and with some allowance this prophecy has been verified.

LABOR organizations, such as the Knights of Labor, are generally regarded as essentially the product of the last few years, but we are reminded again that there is nothing new under the sun by reading the following in Don Manael Gonzale's account of London, written in 1731. Speaking of domestic servants, he says: "They form themselves into societies, or rather confederacies, contributing to the maintenance of each other when out of place, and if any of them cannot manage the family where they are entertained, as they please, immediately they give notice they will be gone. There is no speaking to them—they are above correction."

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